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Preliminary Draft
March 31, 1972

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DRAFT
ENVIRONMENTAL STATEMENT
FOR THE
PROPOSED PROTOTYPE OIL SHALE LEASING PROGRAM
IN
COLORADO - UTAH - WYOMING
TRACT OFFERING SUPPLEMENT

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THE
UNITED STATES
DEPARTMENT OF THE INTERIOR

APRIL 1972

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1. Description of the Proposal

1. Description of Proposal to Offer Lands in Colorado, Utah and Wyoming for Prototype Oil Shale Leasing

The oil shale resources of the United States have enormous potential as a future source of oil. Large areas of the United States are known to contain oil shale deposits, but those areas in Colorado, Utah, and Wyoming that contain the shale-rich sedimentary rocks of the Green River formation are of greatest promise for shale oil production in the immediate future. These oil shales occur beneath 25,000 square miles (16 million acres) of lands, of which about 17,000 square miles (11 million acres) are believed to contain oil shale of potential value for commercial development.

The known Green River formation deposits include high-grade shales, at least 10 feet thick, averaging 25 or more gallons per ton, and containing about 600 billion barrels of oil. Of most immediate significance are about 80 billion barrels of oil contained in the more accessible higher grade deposits. These are considered available with present methods of extraction, and nearing economic competitiveness with petroleum of comparable quality.

No shale oil is being produced commercially in the United States at this time. However, research and development by the Bureau of Mines since the mid-1940's, and by industry and universities for almost as long, has provided the technological framework considered applicable to commercial oil shale operations that use mining-surface processing techniques. One pilot operation on private lands with a 1000 tpd capacity has been undergoing test runs and evaluation procedures for the past three to four years. In-situ retorting, in which shale would be heated underground (thus avoiding mining) is relatively untried. Experiments by industry and the Bureau of Mines suggest that in-situ processing may be feasible under certain conditions, but viable processes are not yet proven. Although environmental control technology for an oil-shale industry is yet to be demonstrated, research has indicated that oil shale can be developed in harmony with the existing environment.

Of the 11 million acres of land containing oil shale deposits considered to be potentially of commercial value, some 8.3 million acres (about 72 per cent) are public lands managed by the Federal Government. Under the authority and guidance provided by the mineral leasing laws, the responsibility for managing and leasing public oil shale lands is vested in the Secretary of the Interior.

To stimulate commercial development on public lands, the Interior Department announced on June 29, 1971, plans for a proposed program to permit the development of a small part of the oil shale resources on public lands in Colorado, Utah, and Wyoming. A preliminary Draft Environmental Impact Statement was also released at that time. The prototype program would involve public and industry participation in selecting up to six oil shale tracts--two in each of the three states--to be offered for lease by sealed, competitive bonus bids. The first leases, subject to detailed environmental safeguards designed for each individual tract, would be issued in December 1972 if the tentative timetable is followed.

It is too early to appraise the extent and nature of the interest of private enterprise in obtaining and developing oil shale leases, but if industry views the economic potential of shale oil production as being promising, production of shale oil could reach as much as 900,000 barrels a day by the mid-1980's. More importantly, a foundation could be established for greater shale oil production near the end of the century when it will be urgently needed.

This document is a supplemental draft environmental statement for six tracts (two each in Colorado, Utah and Wyoming) which have been selected for competitive lease offering under the program. Complementary documents related to the program are:

A. Prepared by the Department of the Interior

   1. Draft Environmental Impact Statement for the Prototype Oil Shale Leasing Program, June 1971

   2. Program Statement for the Proposed Prototype Oil Shale Leasing Program, June 1971

   3. U.S. Energy - A Summary Review, January 1972

B. Prepared by the States of Colorado, Utah and Wyoming

   1. Committee on Environmental Problems of Oil Shale, Environmental Problems of Oil Shale, State of Utah, February 1971

   2. Special Committee of the Governor's Oil Shale Advisory Committee, Report on Economics of Environmental Protection for a Federal Oil Shale Leasing Program, State of Colorado, January 1971

   3. Wyoming Oil Shale Environmental Planning Committee, Environmental and Economic Report on Wyoming Oil Shale, State of Wyoming, February 1971

C. Notices in Federal Register

   1. Informational Core Crilling; Federal Register Document 71-9219, filed 6-29-71 (Vol. 36, No. 126, p. 12319)

   2. Call for Nominations of Areas for Oil Shale Leasing; Federal Register Document 71-15959, filed 11-1-71 (Vol. 36, No. 211, p. 20996)

The Department of Interior's oil shale leasing program has two primary goals which are:

(1) to stimulate the development of commercial oil shale technology to ensure that oil from shale will be available as a future domestic supply option and

(2) to do so in a manner that will ensure that the minimum of possible impact on the present environment while providing for the future restoration of the immediate and surrounding affected areas. These objectives have been conditioned with the following guidelines:

The lease terms and regulations will be promulgated to encompass fully the principles of Public Law 91-190 (National Environmental Policy Act of 1969) and Executive Order Number 11514. Part 23 of Title 43 of the Code of Federal Regulations will be further expanded to include model provisions to assure the environmental integrity of the immediate and surrounding areas. These provisions will be designed to insure that the lessee will:

(1) control the release of gases and/or particulate matter within standards established by the U.S. Department of Health, Education, and Welfare and the States of Colorado, Utah, and Wyoming,

(2) prevent thermal pollution and maintain the quality of surface and subsurface waters in the area to comply with water quality standards established pursuant to the Federal Water Pollution Control Act, as amended, and to State statutes

(3) provide for the stablization of spent shale and other operational solid wastes that will be stored on the surface in accordance with mine land restoration regulations of Interior and the States involved,

(4) provide safeguards to prevent contamination of the surrounding lands and waterways by soluble materials and silt leached or washed from spent shale and other solid wastes,

(5) provide safeguards to prevent release of liquid wastes generated in mining or processing operations to the surrounding area and waterways,

(6) provide for control of erosion problems attributable to mining or operational disturbance of the land surface,

(7) preserve and protect other natural and man-made resources within the lease area, including recreational, scenic, and historic values,

(8) protect fish and wildlife and their habitat from damage by mining or surface operations,

(9) provide control for surface subsidence above mined areas in accordance with 30 CFR 231 and lease stipulations for specific tracts, and

(10) restore land surfaces before abandonment to a state commensurate with or better than the original terrain, including revegetation or any solid waste deposits retained on the surface in accordance with 43 CFR 23.

General

Fifteen companies have submitted 23 nominations of tracts they would like to see offered for lease in Interior's proposed prototype oil shale leasing program.

Seventeen of the tracts are in the Piceance Creek Basin of Colorado; five in the Uintah Basin of Utah, and one in the Washakie Basin of Wyoming. Each tract is close to the maximum acreage permitted for an oil shale lease under the Mineral Leasing Act of 1920 - 5,120 acres.

Department officials said they were pleased with the response to the call for nominations which went out November 2, 1971. The time period in which nominations could be made ended January 31, 1972. This is a step in a process which could lead to the offering of not more than six tracts for competitive-bid leasing beginning in December 1972.

The nominations were reviewed by a committee of Federal and State officials for analysis and the selection of tracts for lease offering was based upon their recommendations after review by the Interior Department.

Companies submitting nominations are: American Petrofina of Texas; Ashland Oil, Inc.; Atlantic Richfield Co.; Barodynamics, Inc.; Occidental Petroleum Co.; Geokinetics, Inc.; Gulf Mineral Resources Co.; Marathon Oil Co.; The Oil Shale Corp.; Phelps Dodge Corp.; Shell Oil Co.; Sohio Petroleum Co.; Superior Oil Co.; Sun Oil Co.; and Western Oil Shale Corp. Since only one nomination was submitted for lands in Wyoming, the State of Wyoming has suggested that two additional tracts be considered in making a selection of two tracts for a lease offering. This suggestion was accepted.

Based upon the goals of the Oil Shale Program, the major technologic and resource components were analyzed in the selection of tracts for lease offering. In order to weigh the multiple factors and criteria involved in these components, the following overall criteria were considered in the elimination and selection process:

General Criteria

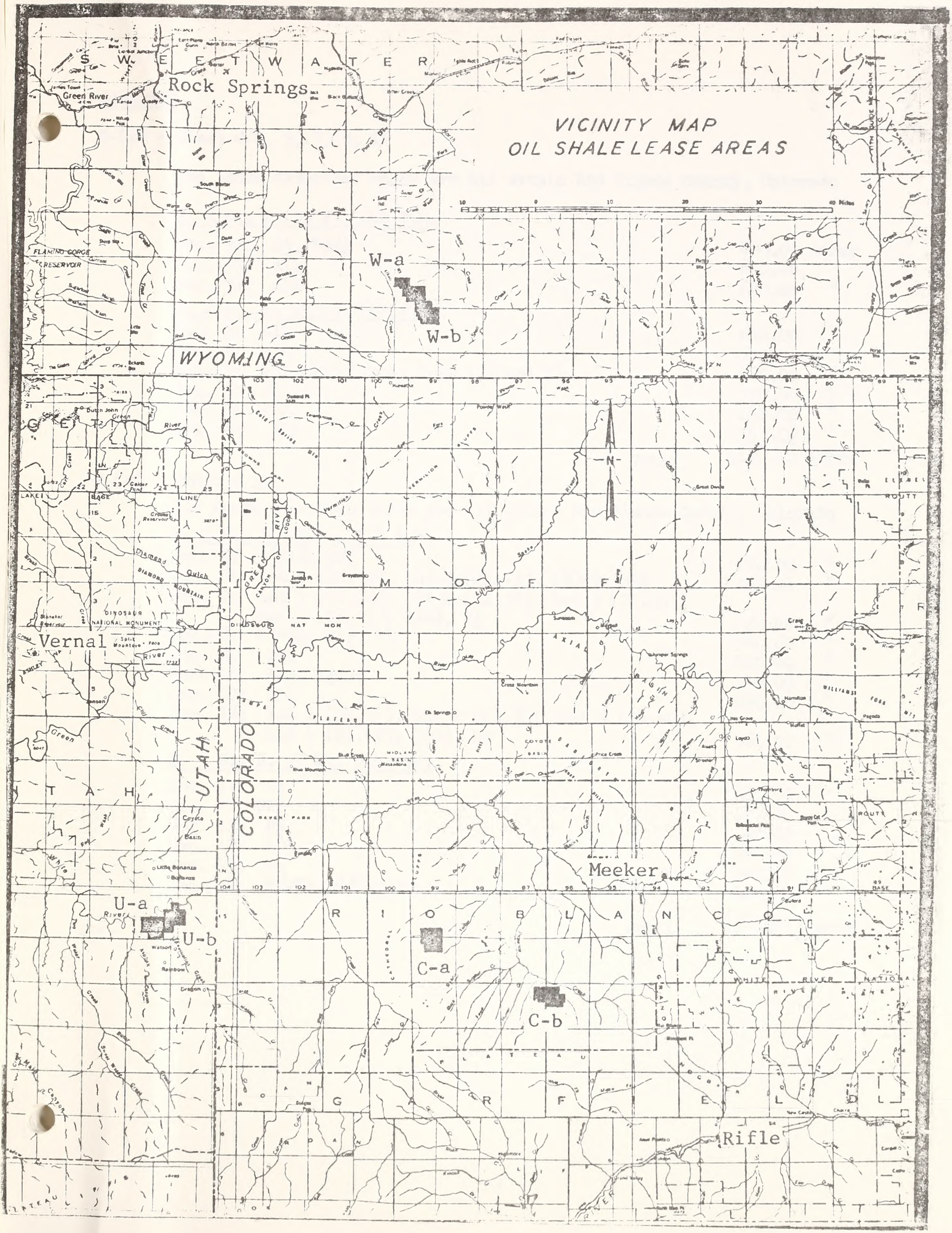
Unusual constraints or inhibiting factors
Recognition and evaluation of environmental conditions and impacts
Areas of apparent interest
Intensity of interest in tract areas
Resource comparability between tracts
Apparent potential for progressive stimulation of technologies
  in multiple horizon or zones
Apparent potential recoverability
Indicated efficiencies of technologies
Area influences including off-site
Sufficiency and reliability of available resource data

The social economic aspects of various stages of development which could be anticipated for two leases in each state are summarized in the Environmental and Program Statement.

There are four basic development technologies which at this time must be considered in weighing advantages and disadvantages of stimulating progressive development. These are:

1. Conventional underground operations.
2. Open-pit operations
3. In-situ extraction
4. Combination underground - in-situ

Based upon these considerations the following tracts of lands have been selected to be offered for leasing under the schedule and conditions outlined in the general environmental and program statements.



VICINITY MAP
OIL SHALE LEASE AREAS

Colorado

C-(a) - Tract C-4, 5, 7, 8, 17

The lands described below are all within Rio Blanco County, Colorado

T. 1 S., R. 99 W., 6th P.M.

Sec. 32:	E½, E½W½	480.00 Acres
Sec. 33:	All	650.40 "
Sec. 34:	All	640.00 "

T. 2 S., R. 99 W., 6th P.M.

Sec. 3:	All	640.00 "
Sec. 4:	All	640.00 "
Sec. 5:	E½, E½W½ (Incl. lots 1,2 and 3)	480.00 "
Sec. 8:	E½	320.00 "
Sec. 9:	All	640.00 "
Sec. 10:	All	640.00 "
	Total	5130.40 Acres

C-(b) - Tract C-13

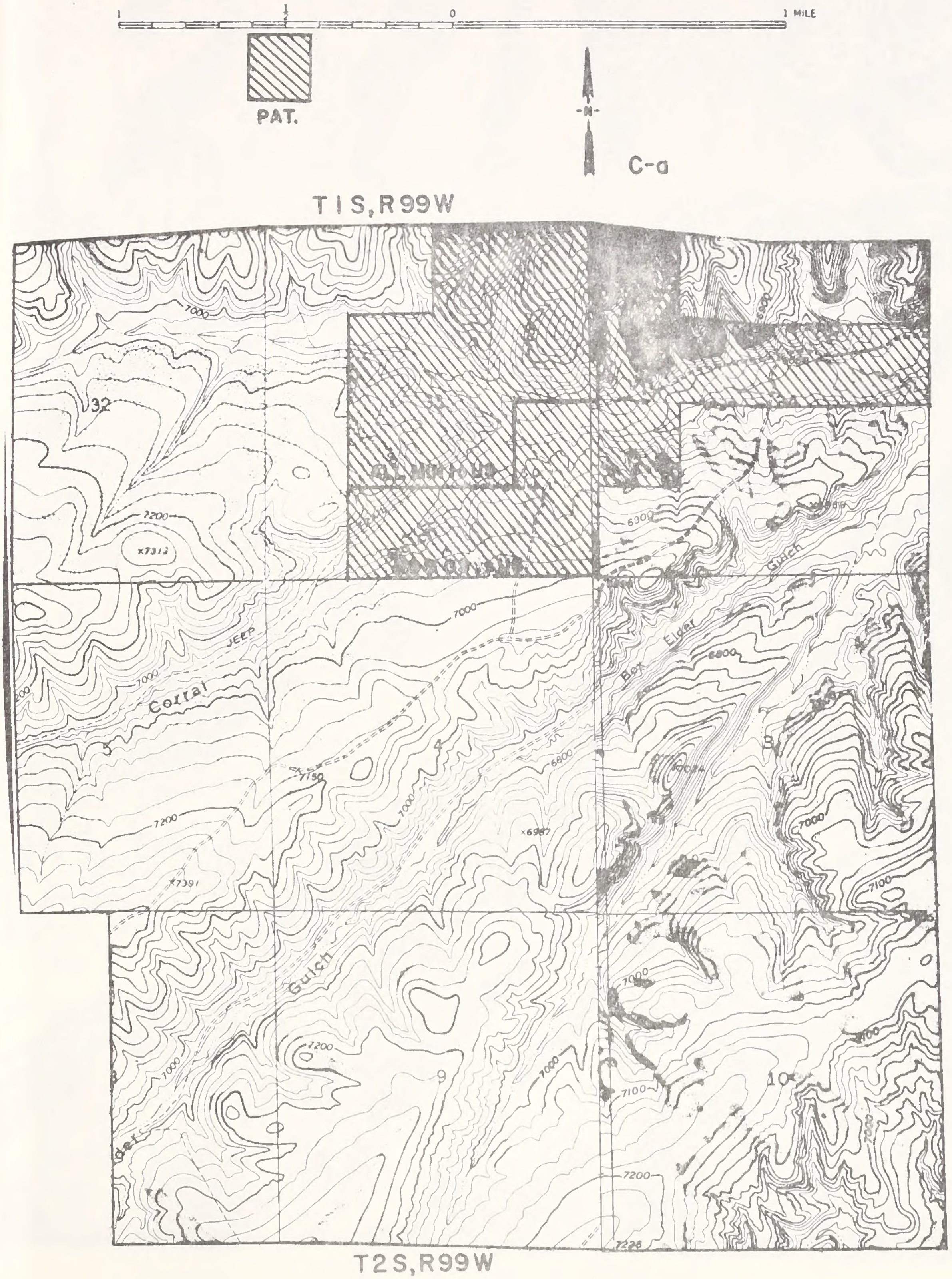
The lands described below are all within Rio Blanco County, Colorado

T. 3 S., R. 96 W., 6th P.M.

Sec. 5:	W½SE¼, SW¼	240.00 "
Sec. 6:	Lot 6 (21.51), Lot 7 (21.43), E½SW¼, SE¼	282.94 "
Sec. 7:	Lot 1 (21.39), Lot 2 (21.37), Lot 3 (21.35), Lot 4 (21.33), E½W½, E½	565.44 "
Sec. 8:	W½NE¼, NW¼, S½	560.00 "
Sec. 9:	SW¼	160.00 "
Sec. 16:	NW¼, W½SW¼	240.00 "
Sec. 17:	All	640.00 "
Sec. 18:	Lot 1 (21.34), Lot 2 (21.36), Lot 3 (21.40), Lot 4 (21.42), E½W½, E½	565.52 "

T. 3 S., R. 97 W., 6th P.M.

Sec. 1:	S½	320.00 "
Sec. 2:	SE¼	160.00 "
Sec. 11:	E½	320.00 "
Sec. 12:	All	640.00 "
Sec. 13:	N½	320.00 "
Sec. 14:	N½NE¼, N½N½S½NE¼	100.00 "
	Total	5113.90 Acres


1
½
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1 MILE
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N
C-a
T1S,R99W
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7000
7200
x7312
JEEP
Corral
7000
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7150
7200
x7391
7000
6800
x6987
6300
Box
Elder
Gulch
6800
8
7000
7100
Gulch
7200
7000
9
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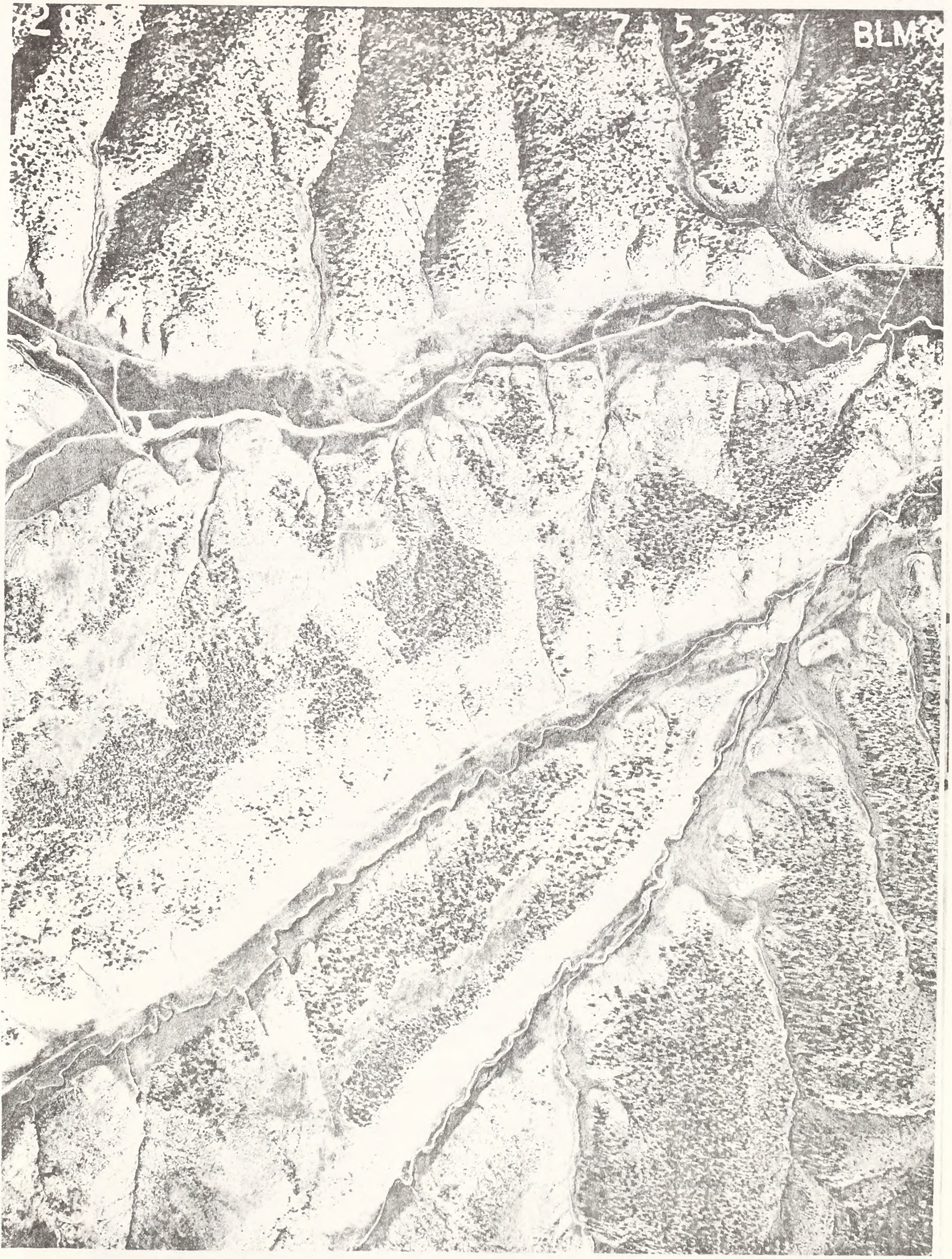
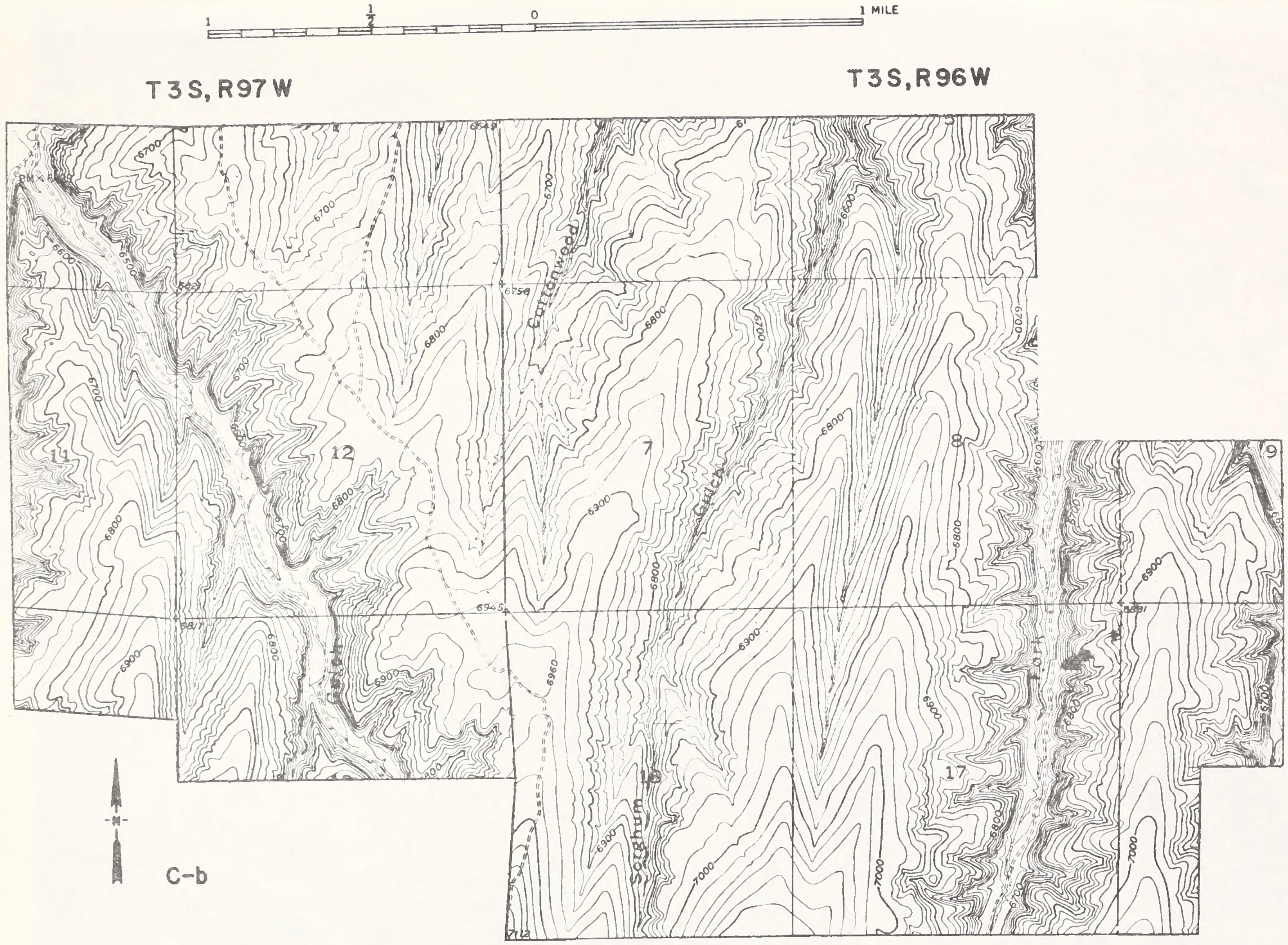
10
7200
7228
T2S,R99W



Tract C-a
Typical Aerial View


1
1/2
0
1 MILE
T3S, R97W
T3S, R96W
11
12
7
8
9
16
17
Cottonwood
Gulch
Gulch
Sorghum
Fork
6500
6600
6700
6800
6900
7000
6960
6945
6758
6849
6891
7112
N

C-b

Tract C-b
Typical Aerial View

Utah

U-(a) - Tract U-2 Modified

The lands described below are all within Uintah County, Utah

T. 10 S., R. 24 E., S.L.M.

Sections: 19: E½
20: All
21: All
22: All
27: All
28: All
29: All
30: E½
32: N½
33: N½

total 5120 acres, more or less

U-(b) - Tract U-4 and U-5 modified

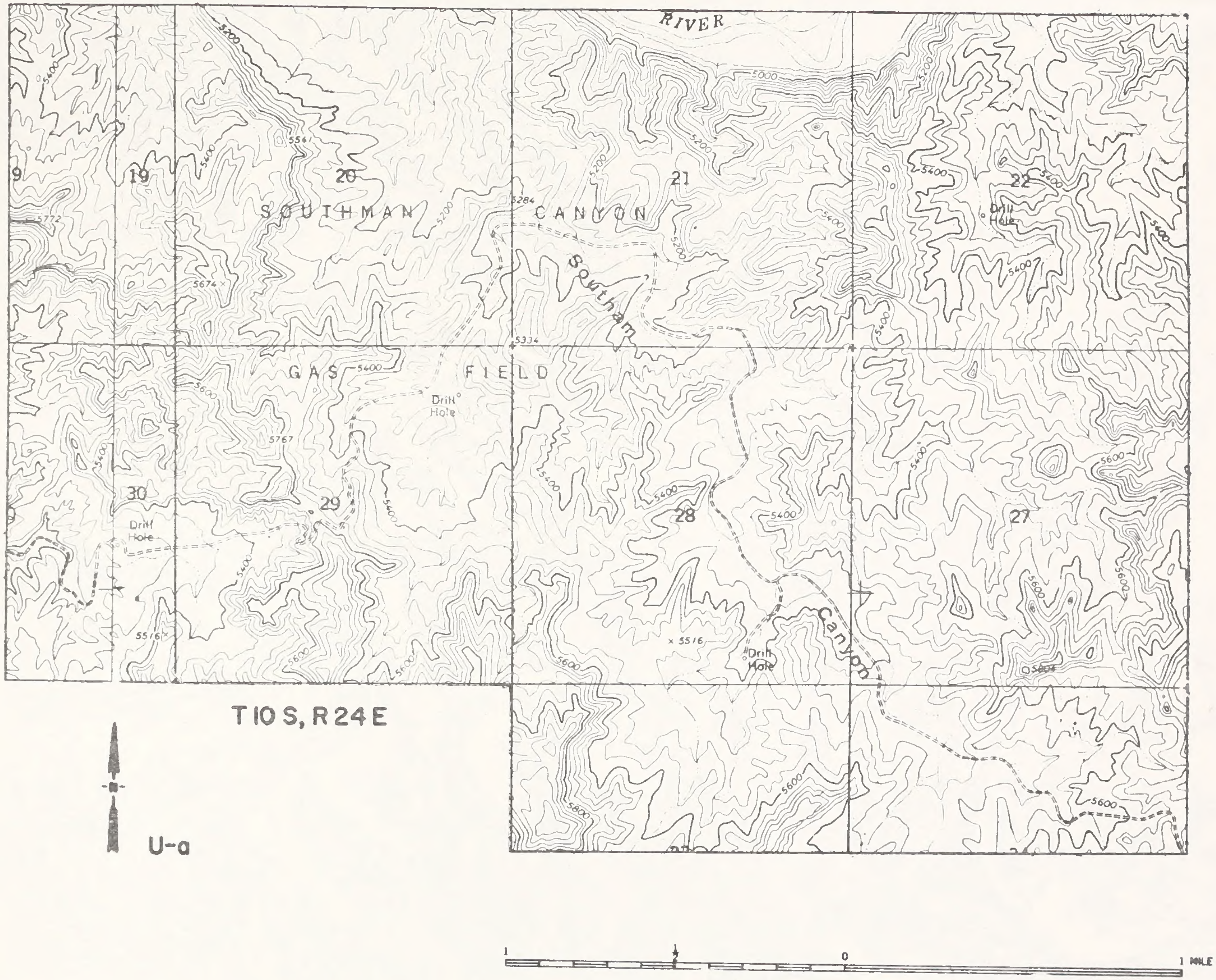
The lands described below are all within Uintah County, Utah

T. 10 S., R. 24 E., S.L.M.

Sections:	12:	S½, S½N½	480 acres
	13:	All	640
	14:	All	640
	23:	All	640
	24:	All	640
	25:	W½W½	160
	26:	All	640
		total	5120 acres

T. 10 S., R. 25 E., S.L.M.

Sections	18:	All	640 "
	19:	All	640 "


RIVER
SOUTHMAN CANYON
Southam
GAS FIELD
Canyon
9
19
20
21
22
30
29
28
27
Drill Hole
Drill Hole
Drill Hole
Drill Hole
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5200
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5600
5800
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5334
5541
5674
5772
5767
5516
5516
5604
T10S, R24E
U-a
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½
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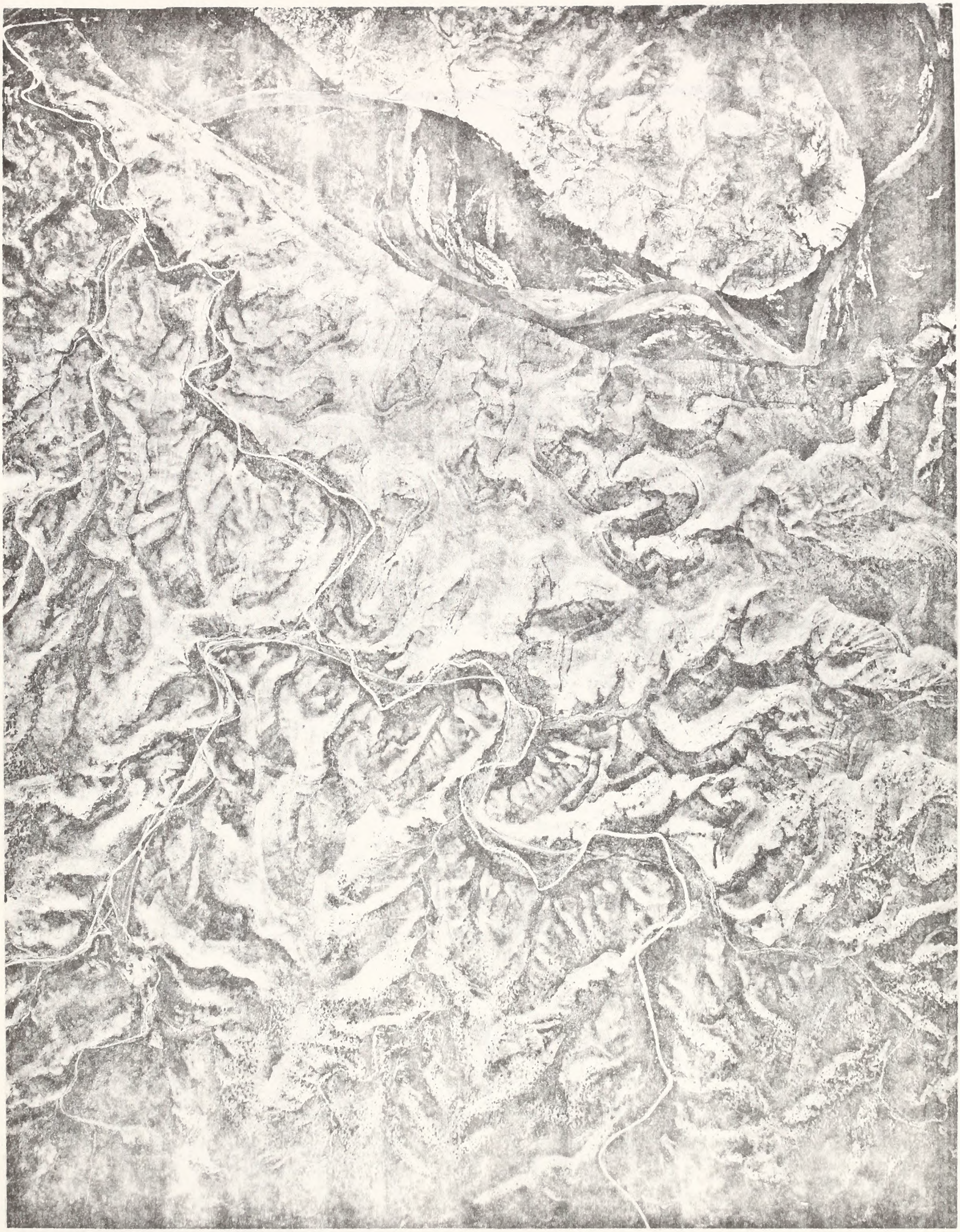
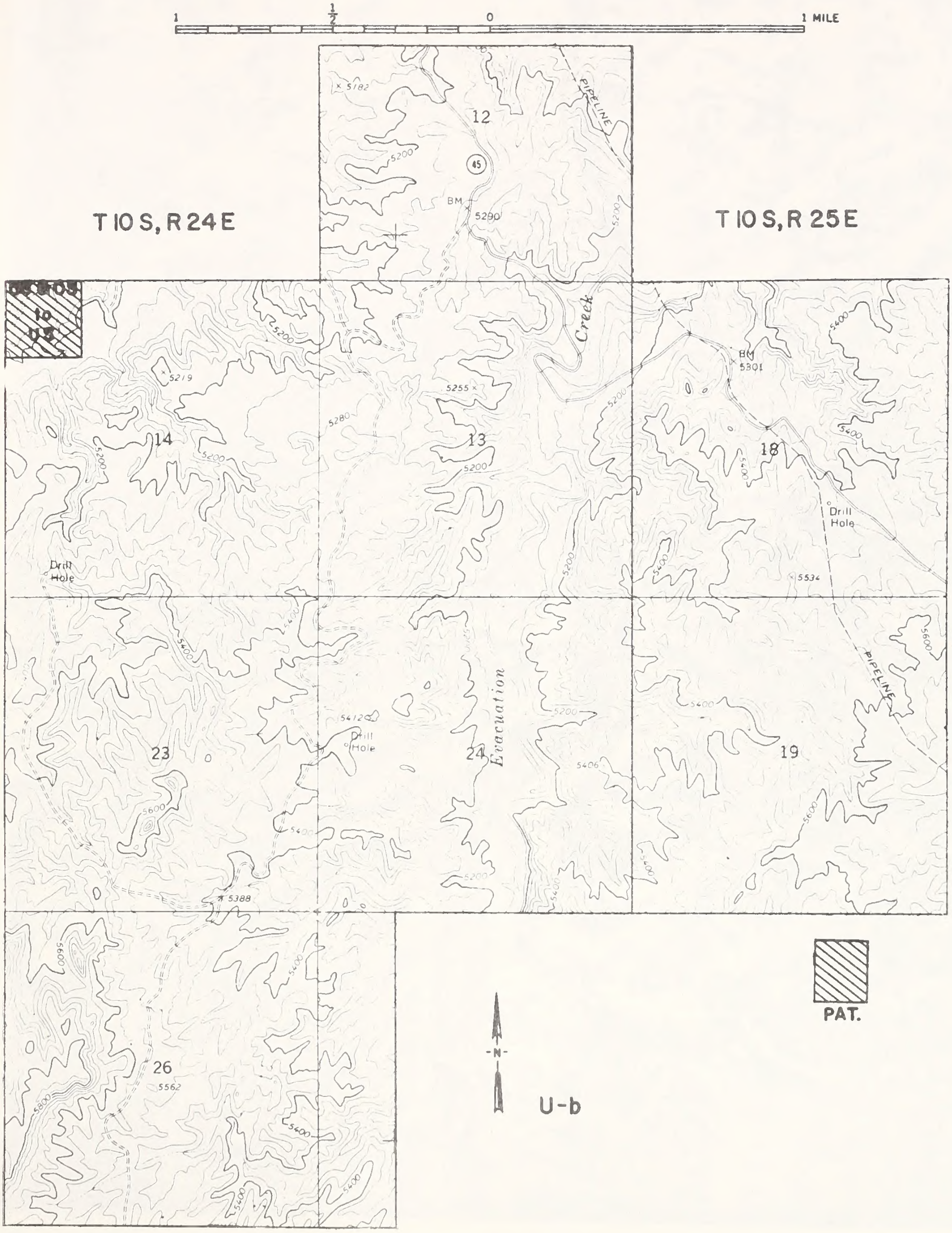
1 MILE



Tract U-a
Typical Aerial View


1
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1 MILE
T10S, R24E
T10S, R25E
12
13
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18
19
23
24
26
PIPELINE
PIPELINE
45
BM 5290
BM 5301
Creek
Evacuation
Drill Hole
Drill Hole
Drill Hole
5182
5219
5255
5280
5412
5388
5534
5562
5406
5200
5400
5600
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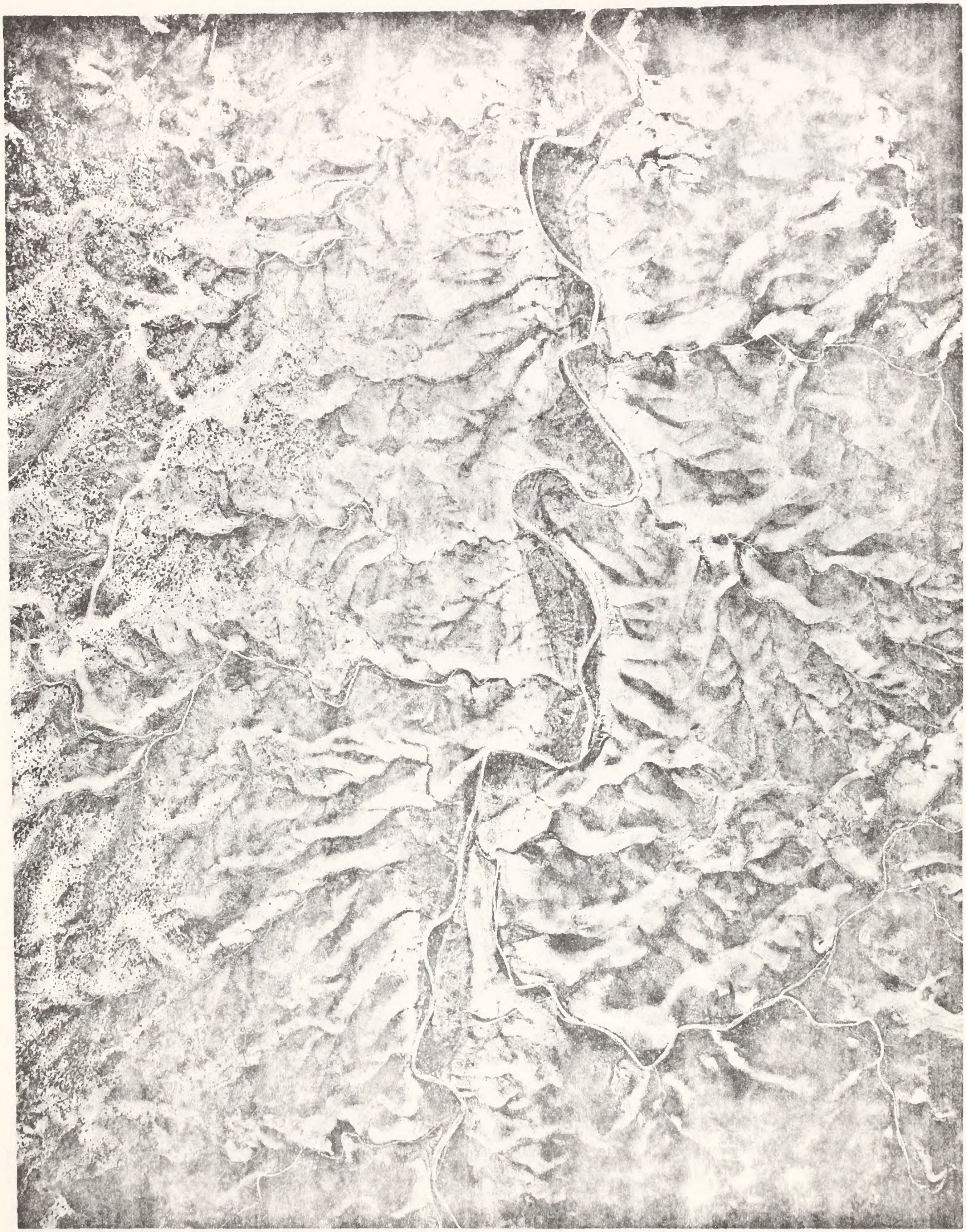


Tract U-b
Typical Aerial View

Wyoming

W-(a) - Tract W-1 (Nominated Tract)

The lands described below are all within Sweetwater County, Wyoming

T. 14 N., R. 99 W., 6th P.M.

Sections	17:	All	
	18:	All	
	19:	NE¼	
	20:	All	
	21:	All	
	22:	All	
	27:	All	
	28:	All	
	29:	N½, SE¼	total 5120 acres, more or less

W-(b) - Tract W-2 (Tract Suggested by State of Wyoming)

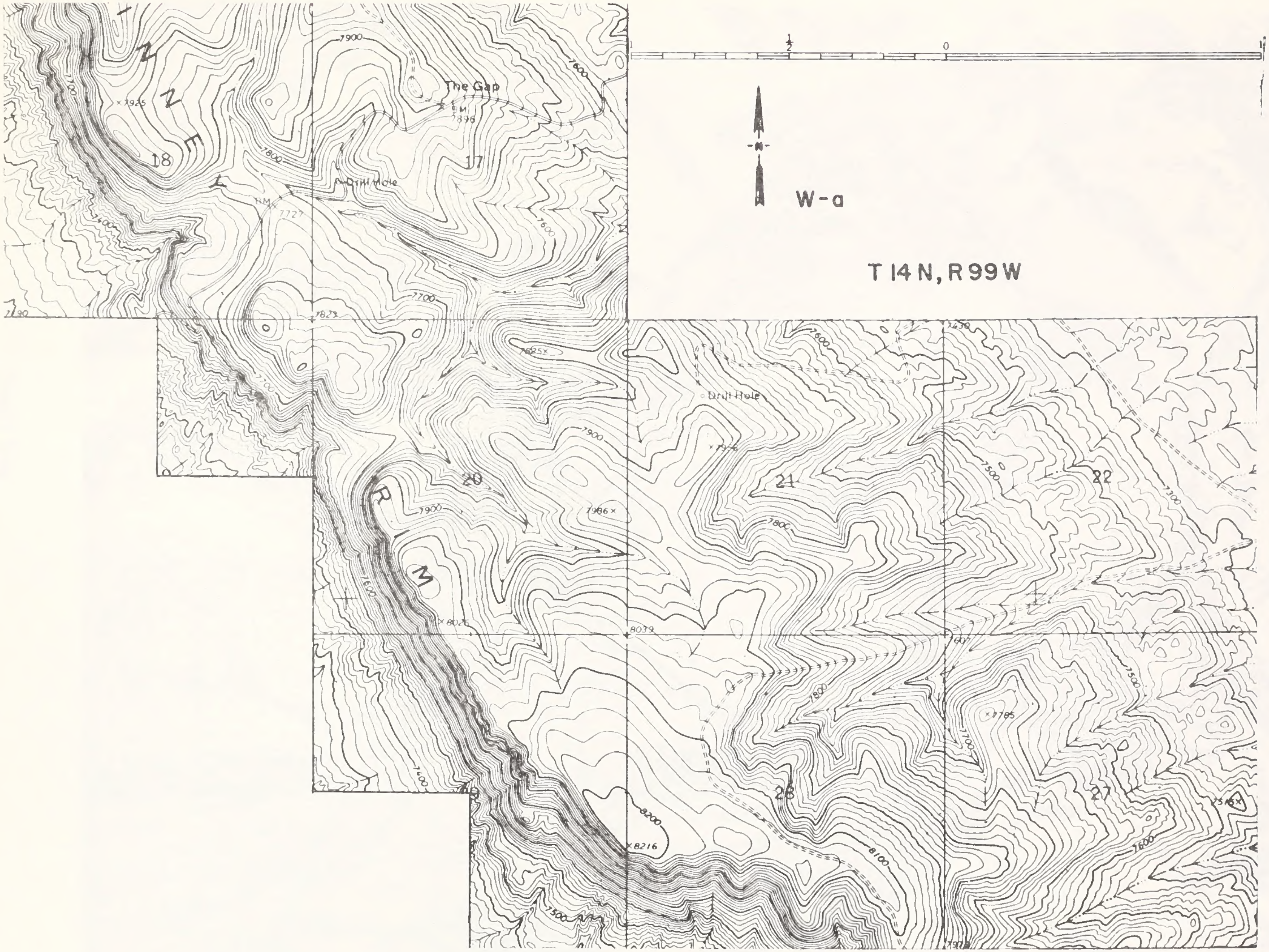
The lands described below are all within Sweetwater County, Wyoming

T. 13 N., R. 99 W., 6th P.M.

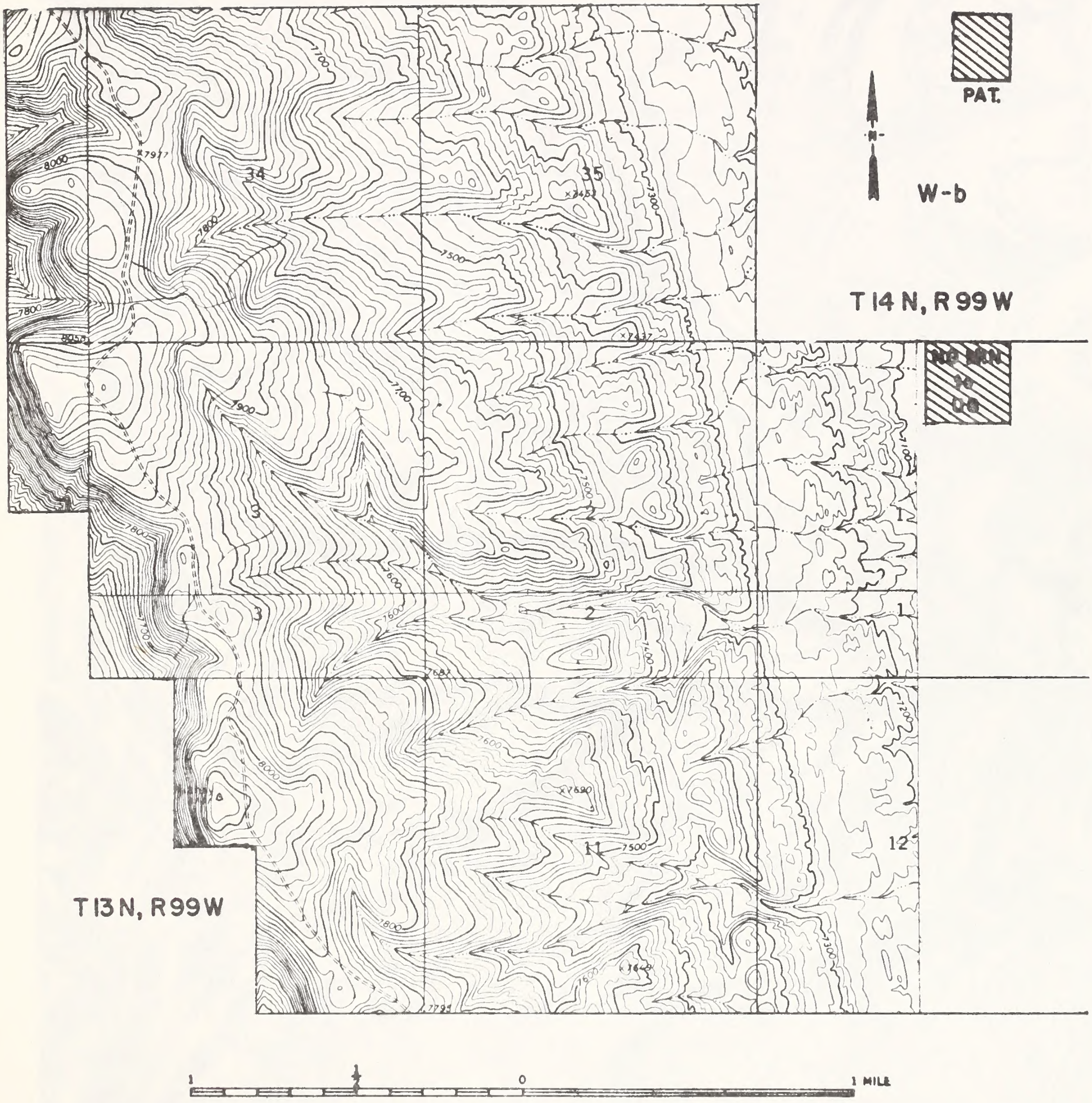
Sections	1:	S½, S½N½, N½NW¼, NE¼NE¼	601.26	Acres
	2:	All	642.15	"
	3:	All	640.36	"
	4:	Lot 1, SE¼NE¼	79.70	"
	10:	E½, E½NW¼	400.00	"
	11:	All	640.00	"
	12:	All	640.00	"

T. 14 N., R. 99 W., 6th P.M.

Sections	33:	E½E½	160.00	"
	34:	All	640.00	"
	35:	All	640.00	"
		Total	5083.47	


W-a
T14N, R99W
1
½
0
1
The Gap
BM
7896
Drill Hole
BM
7727
18
17
20
21
22
28
27
7900
7800
7700
7600
7400
7925
7823
7925
Drill Hole
7986
7900
7800
7600
7500
7300
8026
8039
8200
8216
8100
7785
7516
7430
7790
7500
7400
7978

Tract W-a
Typical Aerial View


PAT.
N
W-b
T14N, R99W
T13N, R99W
34
35
3
3
2
2
1
1
11
12
8000
7977
7800
7800
7700
7500
7451
7300
8055
7900
7700
7500
7437
7100
7800
7700
7600
7600
7600
7683
7500
7200
8000
7600
7620
7500
7800
7300
7600
7640
7795
1
½
0
1 MILE

Tract W-b
Typical Aerial View

This report has been prepared by a multidisciplinary task force group representing the major interest involved.

Bureau of Mines, U.S. Geological Survey (Geologic and Water Resources Divisions), State of Colorado, Bureau of Land Management, Bureau of Sport Fisheries and Wildlife, U.S. Soil Conservation Service, Environmental Protection Agency

DESCRIPTION

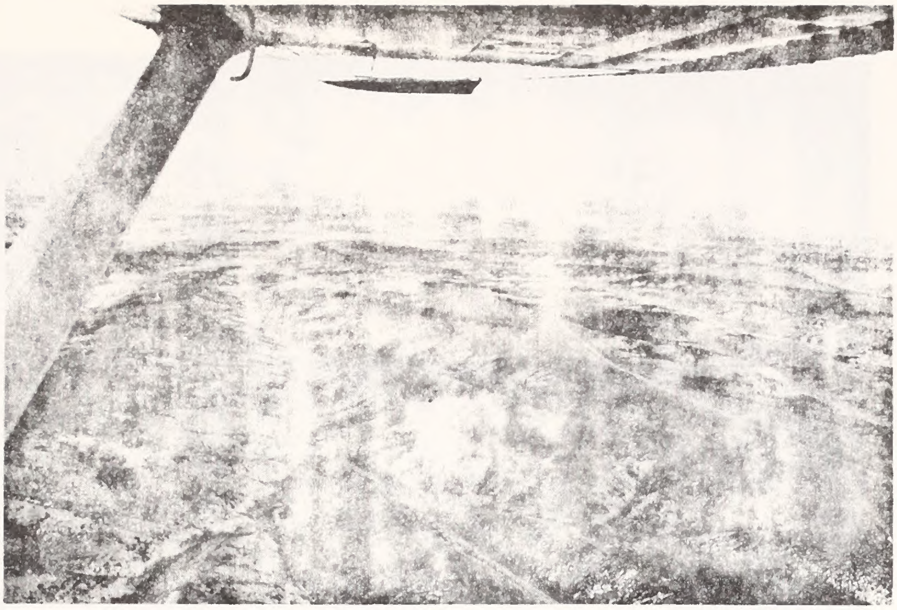
of the

ENVIRONMENT

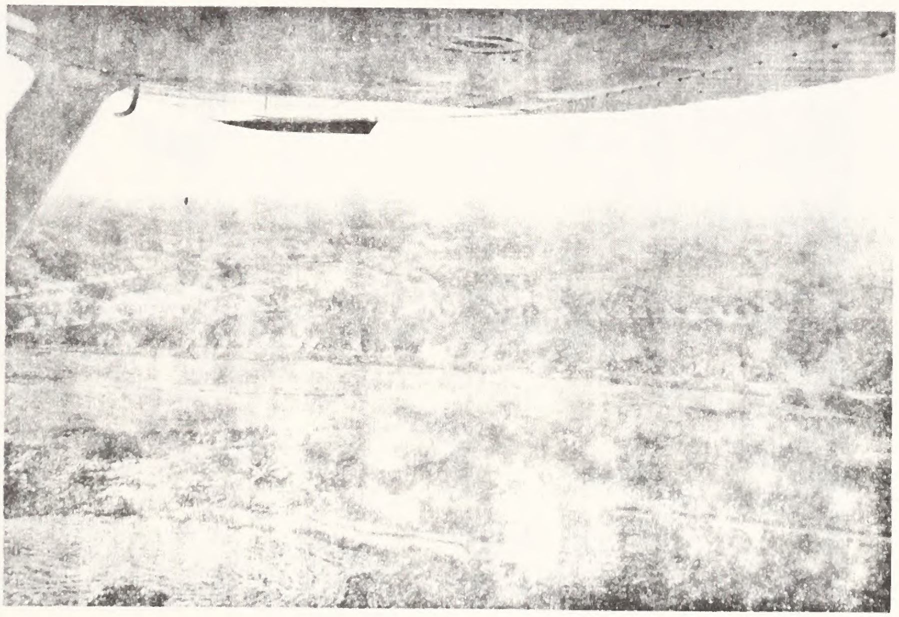
2.a.1 -- Physiography (Colorado)

Tract C-a is located on the west flank of the Piceance Creek Basin. The topography of the area is characterized by northeast-trending subparallel canyons and ridges. The slopes of the canyon walls are steep with a few ledges of oil shale breaking the slopes. The valley floors are narrow and the ridges are broad and rounded and both slope gently northeastward. Altitudes within the tract range from about 6,600 feet on Corral Creek near the northeast corner to about 7,400 feet on a ridge in the southwestern part. Greatest relief from valley bottom to nearby ridgetop is about 300 feet.

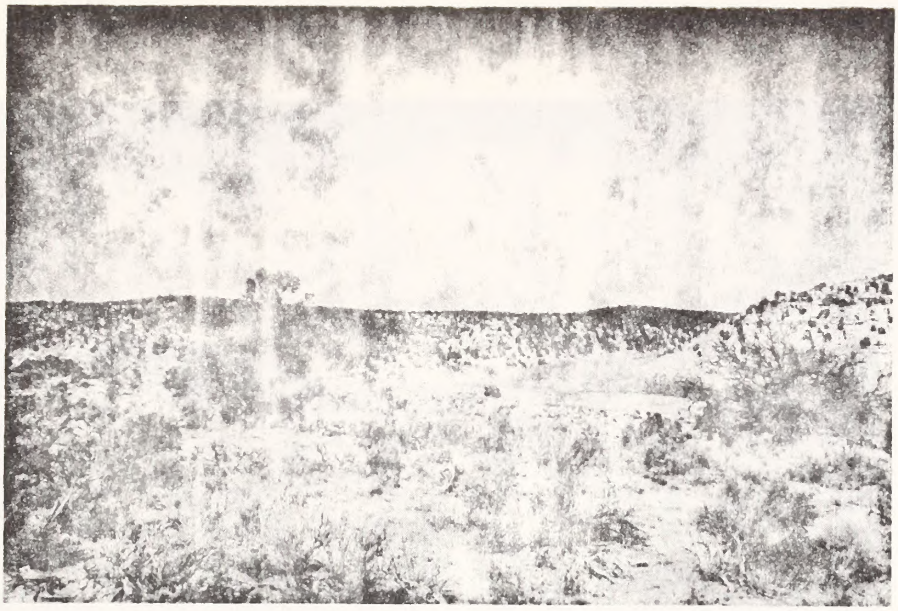
Tract C-b is located in the central part of the Piceance Creek Basin, a short distance southwest of Piceance Creek. The topography is characterized by narrow, steep-walled canyons and broad rounded ridges. The general topographic form is that of a northward sloping plateau that has been dissected by north flowing streams draining into Piceance Creek. Altitudes in the tract range from about 6,400 feet in the northeast corner on Stewart Gulch to about 7,100 feet on a ridge in the south-central part. Greatest relief from valley floor to nearby ridge top is about 400 feet.



Site a Aerial View - A general view looking northeastward down Box Elder Gulch at the eastern half of the site.

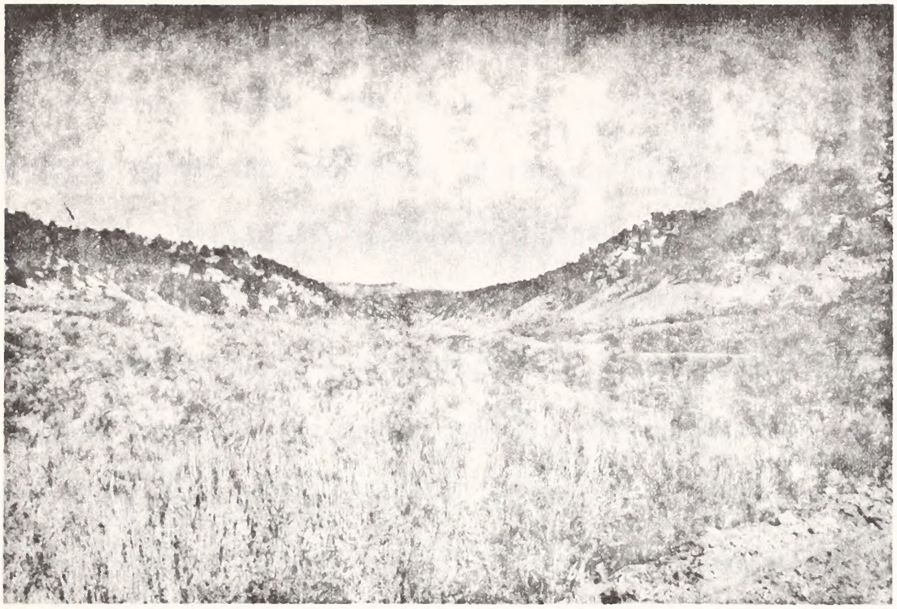


Site b Aerial View - The photo was taken from near the west line of site b looking eastward and showing the entire site.



Site C-a - Ground View - Typical Topography on Site C-a.

Ground View - Looking eastward toward the proposed spent shale disposal area on east Douglas Creek for Site C-a.



Site C-b - Ground View - Typical Valley Topography and Vegetative Complex (Scandard Gulch).

2.a.2 -- Physiography (Utah)

Tract U-a is located immediately south of the White River in the eastern part of the Uinta Basin. The valley of the White River occupies a narrow strip about 800 feet wide in the north-central part of the tract. Southam Canyon, a slightly meandering drainage, extends northwestward across the tract and joins the White River just outside the tract. Numerous minor drainages are tributary to Southam Canyon and to White River, the only perennial stream. The topography is characterized by high, sinuous ridges bounded by cliffs and separated by lower areas of narrow branching ridges and stream valleys. Innumerable small buttes are spread randomly along the drainage divides. Altitudes within the tracts range from about 4,900 feet on the White River to about 5,960 feet in the south-central part. Greatest altitude difference in a short distance is about 450 feet in one-half mile in the south-central part of the tract.

Tract U-b is located immediately south of the White River in the eastern part of the Uinta Basin. The White River, only perennial stream in the tract, flows across the northwestern corner. The canyon of Evacuation Creek trends northward across the central part of the tract. East of Evacuation Creek the topography is characterized by rounded furcated ridges with scattered ledges and cliffs. West of Evacuation Creek the terrain is more rugged and is characterized by ledges and cliffs along the canyon walls and numerous buttes along the drainage divides. Altitudes range from 4,950 feet along the White River to about 5,850 feet near the

A view of the central portion of Utah Site "a" from the N½ of Sec. 28, T. 10 S., R. 24 E.

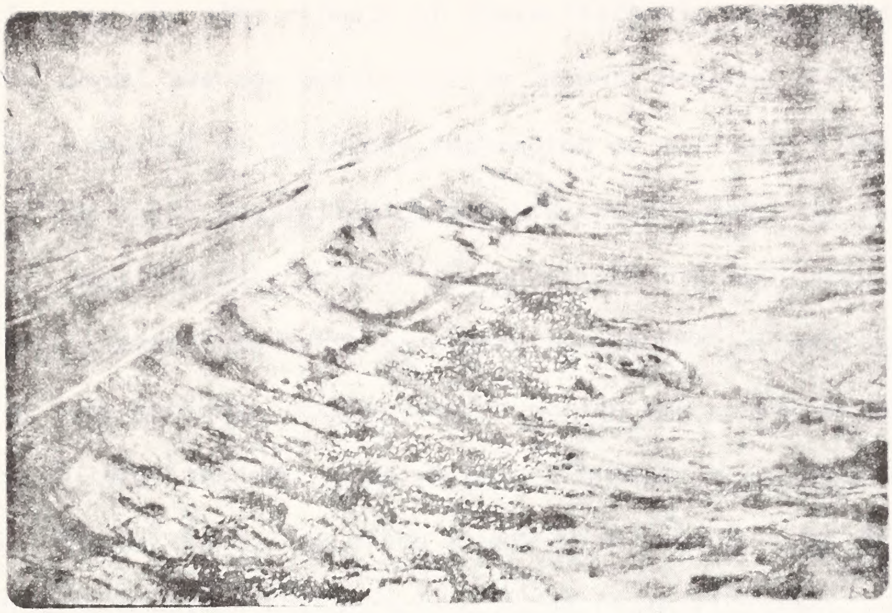
A view looking west across Evacuation Creek from Sec. 13, T. 10 S., R. 24 E., of the NW portion of Utah Site "b"

southwest corner. Greatest altitude difference in a short distance is about 300 feet in one-half mile in the southwestern part of the tract.

2.a.3 -- Physiography (Wyoming)

W-a is located on the southwestern flank of the Washakie Basin and includes part of the Kinney Rim. A southwest-facing escarpment, below the Kinney Rim, extends along the western side of the tract. To the east of the escarpment the topography is controlled by resistant strata that form dip slopes inclined northeastward. A few narrow, steep-sided drainages have been cut into this slope. Altitudes within the tract range from about 7,200 feet at a point below the Kinney Rim escarpment and on the dip slope in the eastern part of the tract to about 8,200 feet on the Kinney Rim. Maximum relief along the escarpment is about 900 feet.

W-b is located on the southwestern flank of the Washakie Basin. The west-facing escarpment below the Kinney Rim extends approximately along the western margin of the tract. East of the escarpment the surface slopes rather uniformly eastward except where broken by narrow east-trending drainages. The relief along most of these drainages is less than 200 feet. Altitudes within the tract range from about 7,100 feet near the eastern boundary to about 8,200 feet on Kinney Rim. Greatest relief on the escarpment along the west side is about 700 feet.



Aerial Photograph-Kinney Rim. Looking SE from Sec. 2, T. 14 N., R. 100 W., toward Wyoming Sites a & b in the upper center and right portions of the photograph.

2.b.1 -- Climatology (Colorado)

Tracts C-a and -b The climate of these tracts is classified as semi-arid with annual average precipitation amounts ranging from about 10 inches to a maximum of 18 inches, depending on altitude. The total number of days with precipitation amounts greater than .10 inches is about 40. Approximately half of the annual precipitation occurs as snow. Accumulated snow depth on higher terrain may exceed three feet for short time periods. Precipitation during the warmer months occurs mainly with local thunderstorms which are more frequent over higher terrain. Thunderstorms are often severe with strong local gusty winds and high precipitation rates causing local flash flooding.

The mean maximum temperature in January is about 38° F and the mean minimum about 5° F. The highest recorded in January is 60° F and the lowest is -35° F. The mean maximum temperature in July is about 86° F and the mean minimum about 45° F. The highest recorded in July is 98° F and the lowest is 30° F. The frost free period is approximately 90 days.

Prevailing winds are from a southwesterly direction, but gusty winds may occur from other directions depending on large-scale atmospheric circulation. Local topographic features have a strong influence on wind flow and create well organized mountain and valley wind flow patterns. In all seasons when local flow regimes predominate the most frequent wind direction is from the northeast (upslope) during the warmer part of the day; and the most frequent direction during the colder part of the day is from the southwest.

Night-time temperature inversions occur with high frequency over the Piceance Basin in the lower few hundred meters above the terrain because of strong radiative cooling in a rather dry atmosphere.

2.b.2 -- Climatology (Utah)

Tracts U-a and -b The climate of these tracts is semi-arid with annual precipitation amounts ranging from about 8 inches at lower elevations to 10 inches over higher terrain. Near the site about 10 inches of precipitation occur per year with about 4 inches from May to September mostly from thunderstorms, and 6 inches October to April associated with maritime polar air masses moving over the area from west and northwest. Approximately 25 days per year have precipitation amounts in excess of .10 inches. Severe local, summer thunderstorms may cause strong gusty winds and local flash flooding. The average annual snow accumulation is about 10 inches. Open areas may remain free of snow for most of the winter.

The area has dry hot summers with an average July maximum temperature of 95° F and an extreme of 105° F. The winters are relatively dry with cold temperatures. The extreme minimum recorded is -25° F, and an average minimum for January of 8° F. The frost free period is approximately 110 days.

The prevailing winds are from the west and southwest with large local variations in lower levels because of mountain and valley wind patterns. The general drainage flow is from the Roan Plateau northward to the White River; therefore, the wind direction would be southerly when local flows predominate during the cooler part of the day when strong inversion conditions exist.

The mean maximum mixing depth is about 400 meters of the Basin in January, and approximately 3,200 meters in July. A high frequency of night-time inversions, particularly during the fall and winter season created limited atmospheric dispersion.

2.b.3 -- Climatology (Wyoming)

The climate of these tracts is semi-arid with annual precipitation ranging from 10 to 12 inches which occurs mostly in the winter and early spring. Temperature fluctuates from 40° F. (Fahrenheit) below zero to 90° F. Extreme temperatures have been recorded in the area at 55° F below zero and 107° F.

The growing season ranges from 70 to 100 days between killing frosts. A killing frost is judged to 28° F or less. The area has 65 to 75 percent of sunshine during possible daylight hours; the percentage lower during spring and winter and higher in the summer and fall. Winds are relatively strong over the area especially along the top of the Kinney Rim. The prevailing wind direction is from the West. During the cooler times of the day downslope winds are from the southwest, and during the warmer times of the day winds blow from the northeast. The most severe weather conditions occur with Arctic outbreaks with northeasterly winds and extremely cold temperatures.

The mean maximum mixing depth for January is approximately 100 meters in January and 3000 meters in July.

2.c.1 -- General Summary of the Geology and Mineral Resources in the Piceance Creek Basin

Stratigraphy

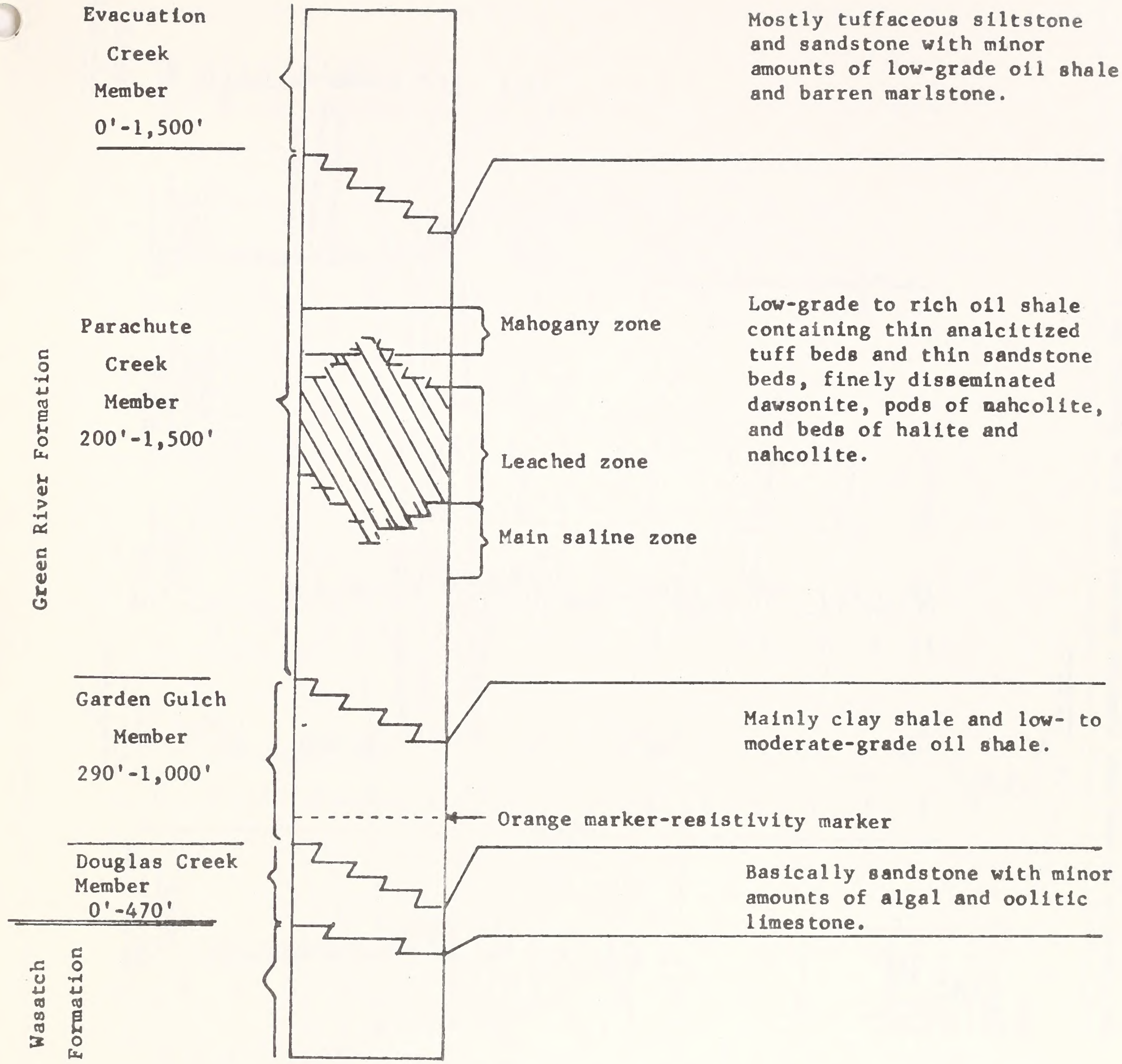
The Green River Formation in most of the Piceance Creek Basin is divided into four members (fig. 1).

Evacuation Creek Member.--Evacuation Creek, the uppermost member, is the surface rock that covers much of the basin. It varies in thickness from 0 feet to 1,500 feet and consists in great part of sandstone and tuffaceous siltstone with minor amounts of marlstone and, in the southern part of the basin, low-grade oil shale.

Parachute Creek Member.--Varies in thickness from 200 feet near the margin of the basin to more than 1,500 feet near the geographic and depositional center of the basin. The Parachute Creek contains most of the rich oil shales in the Green River Formation. Two main oil-shale zones contain all of the oil shale of economic interest.

Upper oil-shale zone.--Encompasses that part of the section from the base of the Evacuation Creek Member to the base of the Mahogany Zone (figs. 1 and 2). Thickness ranges from a few feet near the margin of the basin to more than 500 feet near the Anvil Points mine a few miles west of Rifle.

Lower oil-shale zone.--A thin zone of low-grade oil shale, barren marlstone, sandstone, or siltstone separates the upper and lower oil-shale zones. The lower zone ranges in thickness from a wedge edge at the margin of the basin to more than 1,000 feet at or near the depositional center of the basin. Where best developed the lower oil-shale zone may be divided into a number of sub-zones numbered R-1 to R-6, from bottom to top (fig. 2).


Evacuation Creek Member 0'-1,500'
Mostly tuffaceous siltstone and sandstone with minor amounts of low-grade oil shale and barren marlstone.
Green River Formation
Parachute Creek Member 200'-1,500'
Mahogany zone
Leached zone
Main saline zone
Low-grade to rich oil shale containing thin analcitized tuff beds and thin sandstone beds, finely disseminated dawsonite, pods of nahcolite, and beds of halite and nahcolite.
Garden Gulch Member 290'-1,000'
Mainly clay shale and low- to moderate-grade oil shale.
Orange marker-resistivity marker
Douglas Creek Member 0'-470'
Basically sandstone with minor amounts of algal and oolitic limestone.
Wasatch Formation

Generalized section of the Green River Formation in the area of the typical lease tracts

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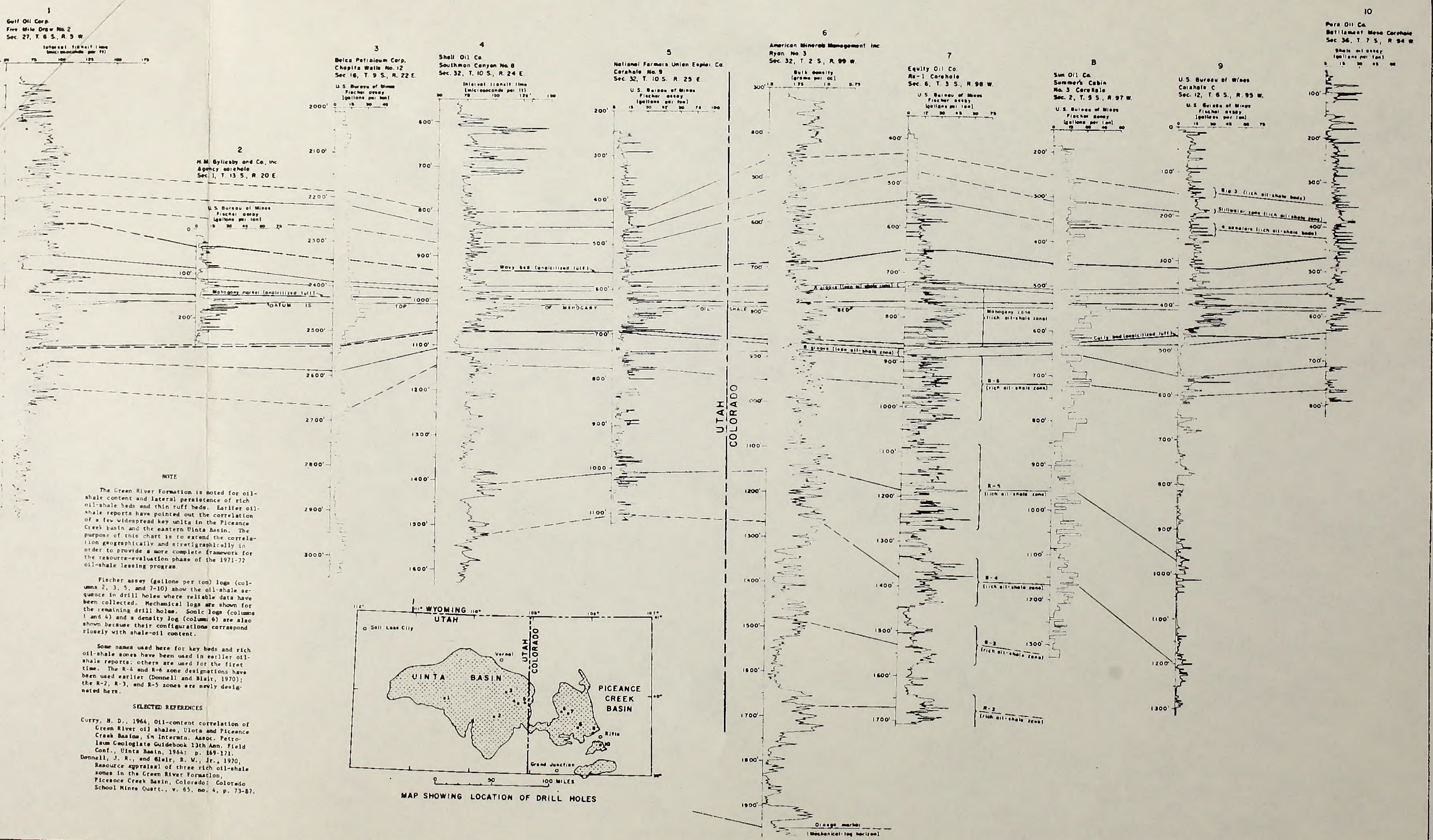
UNITED STATES GEOLOGICAL SURVEY

OIL AND GAS I[illegible]GATIONS
CHART OC 65



MAP SHOWING LOCATION OF DRILL HOLES

NOTE

The Green River Formation is noted for oil-shale content and lateral persistence of rich oil-shale beds and thin tuff beds. Earlier oil-shale reports have pointed out the correlation of a few widespread key units in the Piceance Creek basin and the eastern Uinta Basin. The purpose of this chart is to extend the correlation geographically and stratigraphically in order to provide a more complete framework for the resource-evaluation phase of the 1971-72 oil-shale leasing program.

Fischer assay (gallons per ton) logs (columns 2, 3, 5, and 7-10) show the oil-shale sequence in drill holes where reliable data have been collected. Mechanical logs are shown for the remaining drill holes. Sonic logs (columns 1 and 4) and a density log (column 6) are also shown because their configurations correspond closely with shale-oil content.

Some names used here for key beds and rich oil-shale zones have been used in earlier oil-shale reports; others are used for the first time. The R-4 and R-6 zone designations have been used earlier (Donnell and Blair, 1970); the R-2, R-3, and R-5 zones are newly designated here.

SELECTED REFERENCES

Curry, H. D., 1964, Oil-content correlation of Green River oil shales, Uinta and Piceance Creek Basins, in Intermtn. Assoc. Petroleum Geologists Guidebook 13th Ann. Field Conf., Uinta Basin, 1964: p. 169-171.
Donnell, J. R., and Blair, R. W., Jr., 1970, Resource appraisal of three rich oil-shale zones in the Green River Formation, Piceance Creek Basin, Colorado: Colorado School Mines Quart., v. 65, no. 4, p. 73-87.

CHART SHOWING CORRELATION OF SELECTED KEY UNITS IN THE ORGANIC-RICH SEQUENCE OF THE GREEN RIVER FORMATION, PICEANCE CREEK BASIN, COLORADO, AND UINTA BASIN, UTAH

BY
W. B. CASHION AND JOHN R. DONNELL
1972

OIL AND GAS INVESTIGATIONS

For sale by U S Geological Survey, price 50 cents

Leached zone.--In a large area encompassing several hundreds of square miles saline minerals originally deposited with the oil shale have now been taken into solution by groundwater and the saline water now occupies the voids created by leaching. This unit, known as the leached zone, in places is hundreds of feet thick. The top and base are extremely irregular and extend from the lower part of the Mahogany ledge downward into the lower zone (fig. 1).

Garden Gulch Member.--Varies in thickness from 290 feet near the center of the basin to more than 1,000 feet near the type locality a few miles north and west of rifle. Consists mainly of clay shale. The upper part intertongues with the lower part of the lower oil-shale zone in the Parachute Creek Member. In the Garden Gulch Member the orange marker, a distinctive kick on the resistivity log of wells drilled through the Green River Formation, in general marks the base of oil shale of economic interest.

Douglas Creek Member.--Varies in thickness from 0 feet to 470 feet. Consists mainly of sandstone, with minor amounts of algal, colitic, and ostracodal limestone and in places low-grade oil shale.

Paleontology

Megafossils.--These may be grouped in several general categories--vertebrates, plant remains, and mollusca.

Vertebrates.--Thus far only fragmentary remains of mammals have been found in the Green River Formation. Poorly preserved unidentifiable bone scraps and teeth have been found in the Evacuation Creek Member and readily identified teeth from Early Eocene mammals have been found in exposures of the Douglas Creek

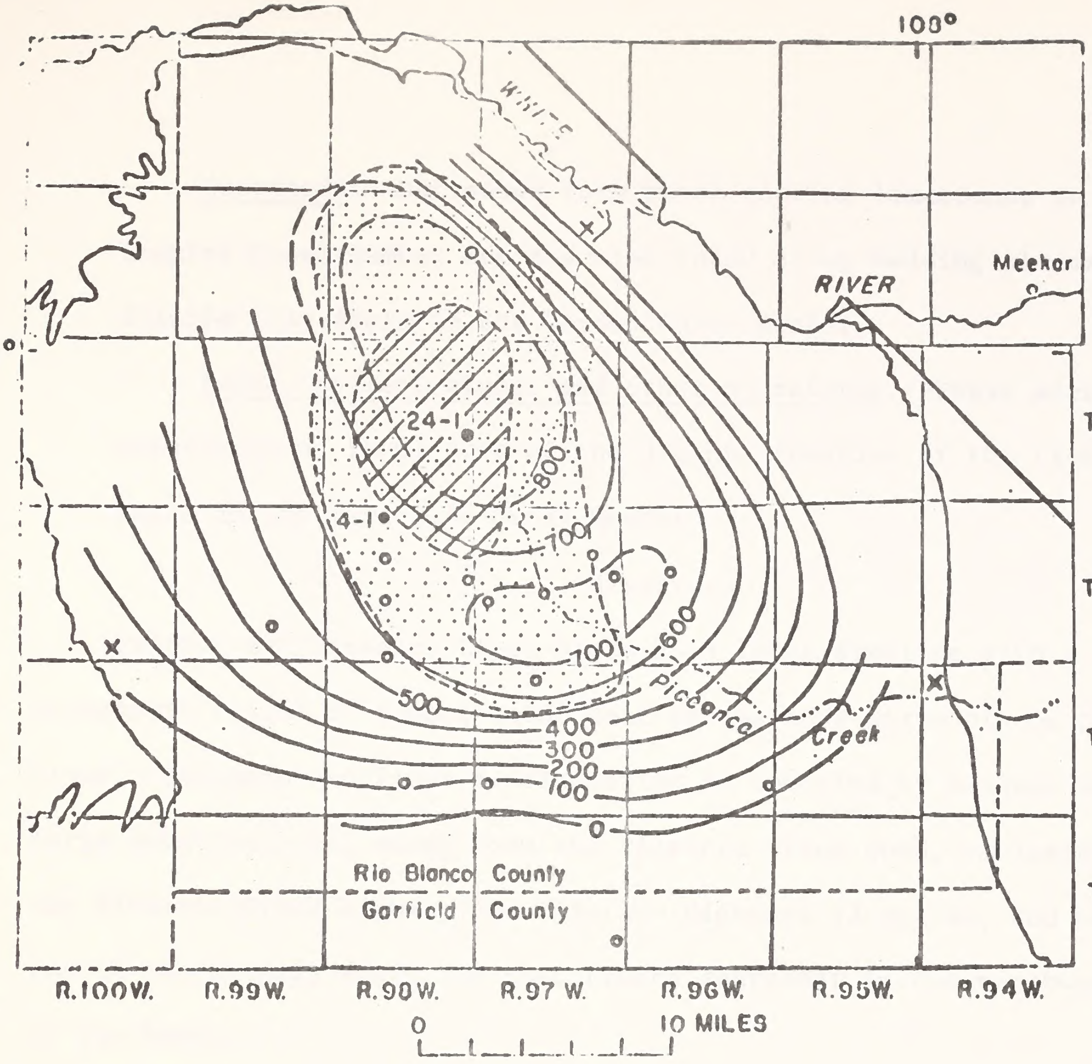
Member along the southwest margin of the basin. A few garpike up to 3 feet in length have been found in the Parachute Creek Member and garpike scales are ubiquitous in the member. Carbonized remains of a small species of herring were unearthed from the Garden Gulch Member at a locality along the Cathedral Bluffs. Numerous turtle and crocodile bones, and occasionally a complete specimen are found in the Douglas Creek Member.

Plant remains.--Several excellent leaf localities have been sampled in the southern part of the basin in marlstones and low-grade oil shales in the upper part of the Parachute Creek Member and the lower part of the Evacuation Creek Member. Poorly preserved leaves and carbonized fragments of twigs, branches, reeds, and other vegetation are scattered through the Evacuation Creek and Parachute Creek Members. Petrified wood covers the surface in a small area east of Piceance Creek.

Mollusca.--Thin beds of limestone and limy sandstone, almost a coquina in places, containing gastropods and pelecypods. These are generally in the Douglas Creek Member but also may be found in the Garden Gulch Member.

Microfossils.--Listed in this category are insects, ostracods, and spores and pollen.

Insects.--Many and varied insects have been collected from localities in the lower Evacuation Creek and upper Parachute Creek Member. The better preserved insects are usually, but not necessarily, restricted to the better leaf localities. Fly larvae are found on the bedding plane of oil shale and marlstone through a thickness of several hundred feet in the upper Parachute Creek Member.



EXPLANATION

☐ Green River Formation

☐ Pre-Green River rocks

░ Area of nahcolite units 1, 2, and 3

▨ Area of halite deposits

—500—
—400—

Isopachs, in feet, for thickness of dawsonite-bearing oil shale. Based on bore-hole data from Smith and Milton (1966), and on unpublished outcrop data from D.A. Brobst (oral comm., 1966). Control wells are shown by circles and outcrop sections by X's.

Figure _____.--Map of the Green River Formation in the northern part of the Piceance Creek basin showing the distribution of dawsonite, three nahcolite units, and halite.

Ostracoda.--Ostracods form thick coquina limestones in the Douglas Creek Member and are also found along bedding planes of the fissile clay shale in the Garden Gulch Member.

Spore, pollen, algae, and other microforms.--These microforms constitute a large part of the organic fraction of the rich oil shale in the Parachute Creek Member.

Structure

Folds.--The Piceance Creek Basin is a large syncline with a structural relief of almost 4,000 feet in the area north of the Colorado River. The main synclinal configuration is modified by several rather large substructures, among them the Piceance Creek dome, enclosed by the Piceance Creek highway and Colorado Highways 13 and 64; and the east end of the Rangely anticline that trends southeast in the northwest part of the basin.

Faults.--A number of northwest trending high-angle normal faults cut the Green River Formation. The faults frequently occur as grabens with the downdropped block containing numerous minor faults with small displacements. The maximum vertical displacement on any fault rarely exceeds 200 feet.

Joints.--Most of the streams west of Piceance Creek that are tributary to Piceance and Yellow Creeks have a pronounced alinement to the northeast or north-northeast. This alinement coincides with the trend of some of the major joint systems. The joint systems are readily mappable along the outcrop of the oil shale. The joints are well developed in the brittle marlstone and low-grade oil shale but are more poorly developed, in most places, in the less brittle Mahogany ledge and some of the rich lower oil-shale zones.

Mineral Resources

Oil shale.--In-place oil-shale resources in the Piceance Creek Basin, in zones thicker than 15 feet that average 15 or more gallons of oil per ton, total about 1¼ trillion barrels of oil. Of this total, about 600 billion barrels are contained in shale averaging 25 or more gallons per ton and 450 billion barrels in shale averaging 30 or more gallons per ton. In the center of the basin the oil-shale sequence is about 2,000 feet thick and individual beds about a foot thick range in value from a few gallons to as much as 90 gallons per ton.

Nahcolite.--A sodium bicarbonate mineral ($NaHCo_3$) that occurs throughout the major part of the Parachute Creek Member. It may be present as elliptical pods that in some places are as much as several feet in diameter, or it may be present as beds that are as thick as 10 or 12 feet. In all parts of the upper oil-shale zone, nahcolite probably averages less than 5 percent by weight, but in thick sequences of the lower oil-shale zone nahcolite may average more than 30 percent by weight. Near the center of the basin where the deposits of nahcolite are best developed, resources of as much as 0.3 billion tons of nahcolite per square mile are indicated (Dyni, 1971). Nahcolite is a potential source of soda ash and may also be useful for removal of sulfur from industrial stack gases.

Dawsonite.--A dihydroxy sodium aluminum carbonate mineral ($(NaAl()H)_2CO_3$) that occurs finely disseminated in the oil shale mainly in the lower oil-shale zone in the part of the Piceance Creek Basin that is in Rio Blanco County. Alumina may be relatively easily extracted from dawsonite; therefore, although the percent of alumina in dawsonite is small, it may be of economic interest. A sequence of oil shale as thick as 800 feet

near the center of the basin contains dawsonite in appreciable quantities. Units of minable thickness may contain 3 percent by weight of extractable alumina.

Halite.--An area of approximately 75 square miles in the north-central part of the basin is underlain by halite. Where it is well developed, the zone containing halite is more than 300 feet thick and has individual halite beds as thick as 30 feet. The halite beds are large units, barren of organic matter, in R-5, one of the richer parts of the lower oil-shale zone.

Geology Tracts Nominated but not Selected

Most of the tracts in Colorado that were nominated for oil-shale leasing lend themselves to group classification.

Group 1.--Tracts 2, 3, and 12 are underlain, at least in part, by oil shale that is marginal or submarginal in thickness and value. Analyses of the Barcus Creek core indicate that tract 3 is underlain by dawsonite-bearing oil shale at least 500 feet thick. Extrapolation from nearby core analyses indicates that probably tracts 2 and 12 also are underlain by a relatively thick sequence of dawsonite-bearing oil shale. Relatively small amounts of nahcolite are present in tract 3 and probably none is present in tracts 2 and 12. If a resource of sufficient size were present, tracts 3 and 12 would be amenable to surface mining.

Group 2.--Tracts 9, 14, and 15 are underlain by a sequence of oil shale about 90 feet thick in the Mahogany zone that has an average yield of 30 gallons of oil per ton. The lower oil-shale zone is poorly developed and contains only a few rich oil-shale beds separated by thick zones of relatively lean oil shale. No halite and very little nahcolite or dawsonite is present. The leached zone, if present, is probably thin and may contain potable water.

Group 3.--Tracts 1, 6, and 11 contain thick rich oil shale in the Mahogany and lower oil-shale zones. Tract 1 contains about 60 feet, tract 6 about 95 feet, and tract 11 about 150 feet of shale that averages 30 gallons of oil per ton in the Mahogany zone. The lower zone contains a minimum of 440 feet in tract 1 and a maximum of 750 feet in tract 11, of shale that averages 30 gallons of oil per ton. The lower zone is intermediate in thickness and value. Dawsonite is present in significant amounts throughout 700 feet of section in the lower zone. Naholite is

present as beds and pods in an interval ranging in thickness from 500 to 700 feet. Saline minerals that were formerly present in the lower part of the Mahogany zone and the upper part of the lower zone have been leached by groundwater and the voids created by leaching are now filled with highly saline water. The leached zone varies in thickness from 300 to 500 feet. The three tracts contain halite in the upper part of the interval just below the leached zone. The thickness of the interval containing halite varies from just a few feet in tract 1 to more than 300 feet in parts of tracts 6 and 11.

Group 4.--Tract 10 contains about 70 feet of shale in the Mahogany ledge that averages 30 gallons of oil per ton and an additional 700 feet of shale in the lower zone that averages 30 gallons of oil per ton. About 600 feet of lower oil-shale zone contains finely disseminated dawsonite in varying amounts. In part of the tract, more than 1,000 feet of section,extending downward from the lower part of the Mahogany ledge, formerly contained saline minerals that have been leached and the voids created by the leaching are now filled with moderately saline water.

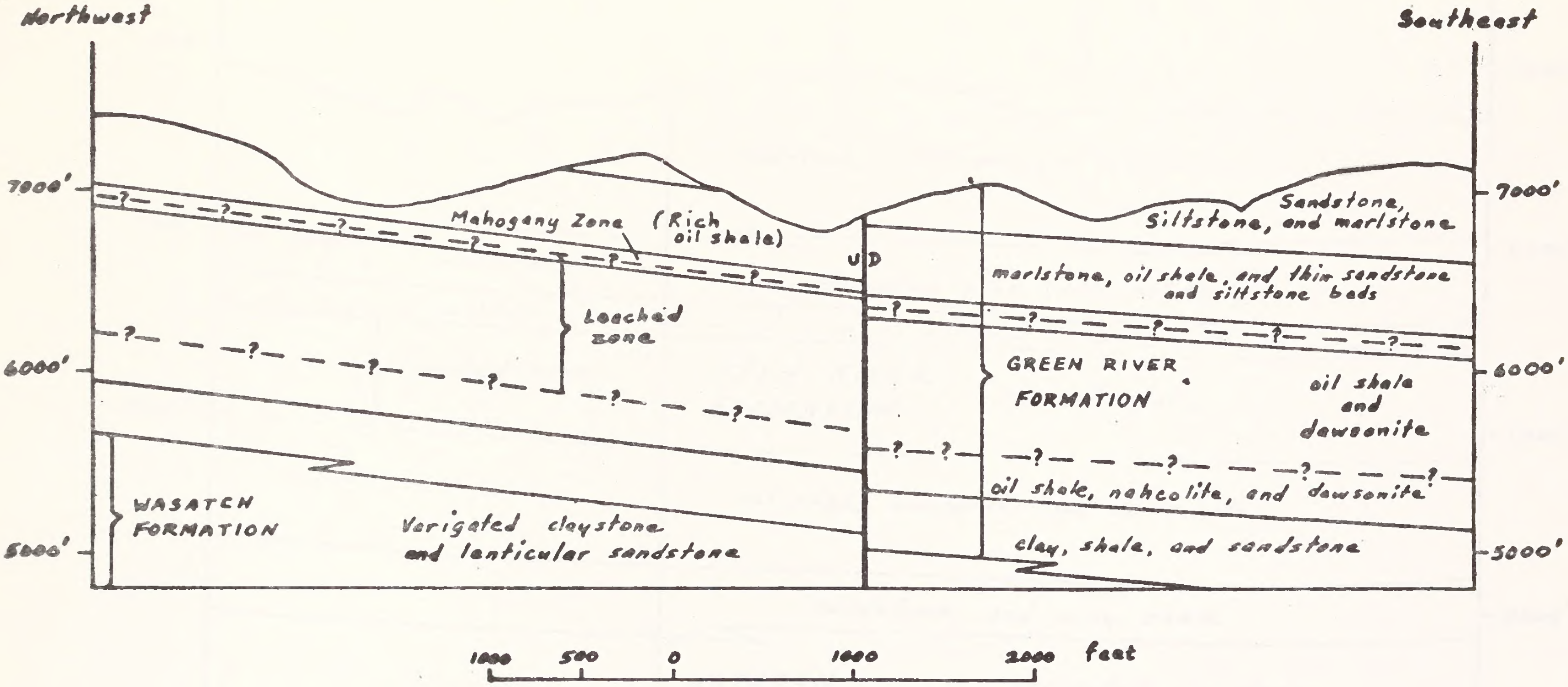
Group 5.--All information for tract 16 is from nearby coreholes. These holes indicate that the thickness and richness of the oil shale and associated minerals changes rapidly in a northerly direction. Shale in the Mahogany zone that averages 30 gallons per ton ranges in thickness from a minimum of about 80 feet to a maximum of about 95 feet. Shale in the lower zone that averages 30 gallons of oil per ton ranges from about 200 feet to more than 700 feet. The part of the lower zone that contains dawsonite ranges in thickness from 500 to 600 feet. Nahcolite, in the lower zone, underlies the entire tract. A sequence of shale starting in the lower part of the Mahogany zone and extending 500 to 600 feet formerly

contained saline minerals that have been leached by groundwater. The water, probably highly saline, occupies the voids created by leaching.

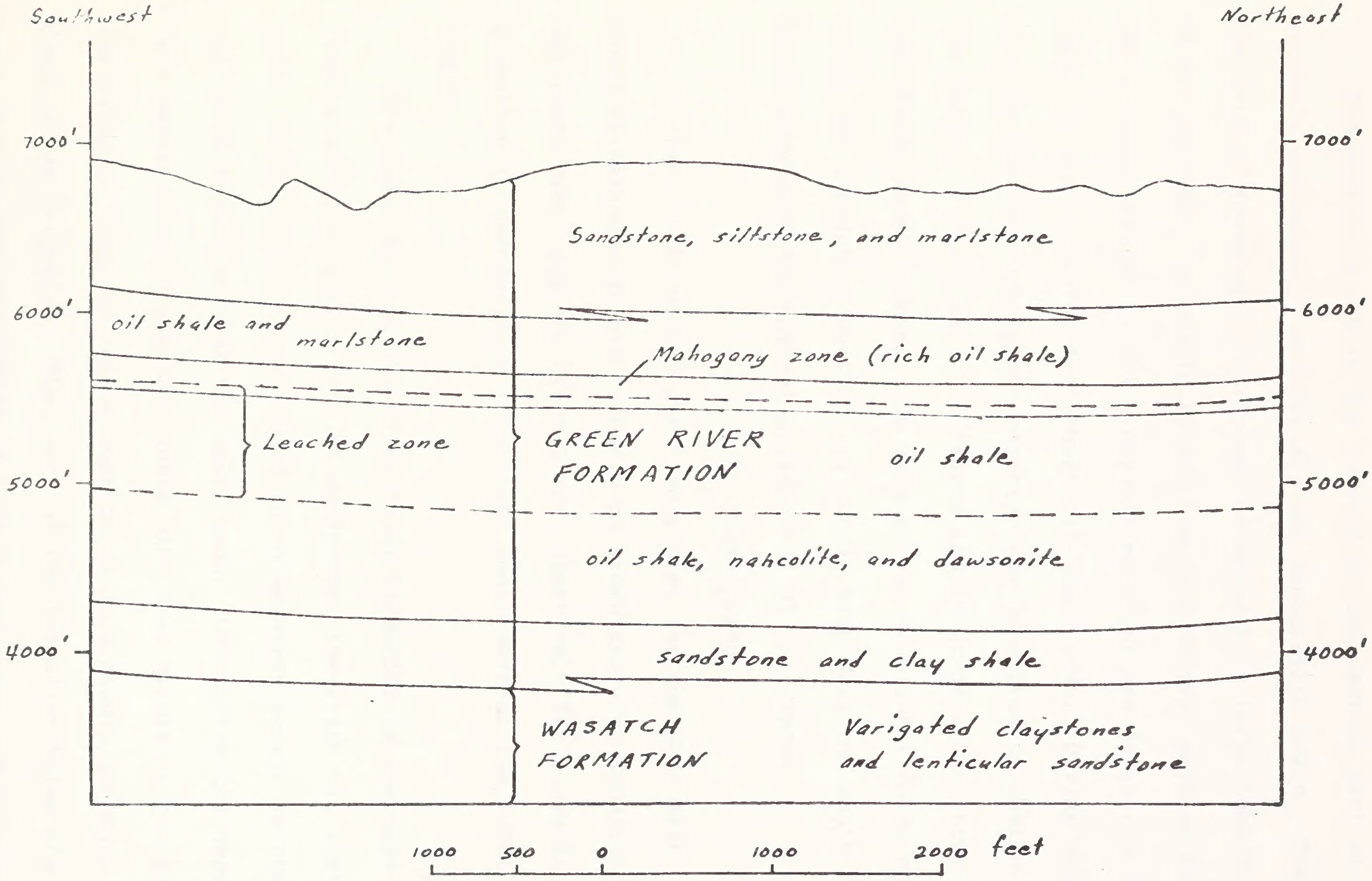
Selected Tracts

Tract C-a contains about 50 feet of shale, in the Mahogany zone, that averages 30 gallons of oil per ton. About 450 feet of shale, in the lower zone, averages 30 gallons of oil per ton. The total in-place shale-oil resource in the two zones is about 1 million barrels per acre. Nahcolite that is present probably does not occur in beds but in pods. Dawsonite probably is present in varying amounts in about 500 feet of section in the lower zone. Several hundred feet of section in the lower zone formerly contained saline minerals that have been leached by groundwater. The water that now occupies the cavities created by leaching varies in quality from potable in the upper part of the zone to moderately saline in the lower part. No oil or gas has been found on Tract C-a; however, commercially significant amounts of gas and small amounts of oil have been produced from the Douglas Creek Member of the Green River Formation, and the Wasatch, Fort Union, and Mesaverde Formations elsewhere in the Piceance Creek Basin. The Fort Union and Mesaverde Formations being considered in the Rio Blanco gas stimulation proposal underlie the entire tract at a depth of 2,000 or more feet below the base of the oil shale. Overburden on the Mahogany zone in the tract ranges from as little as 100 feet to as much as 850 feet and averages about 450 feet. The strike of the rocks is in general to the north and the dip is generally to the east and ranges from 400 feet per mile in the western part of the tract to 300 feet per mile in the eastern part. A northwest-trending graben bisects the area. Maximum measured displacement is 175 feet.

Tract C-b, based on assays from core in nearby holes, varies in value in a northerly direction. Th Mahogany zone contains more than 100 feet of shale that averages 30 gallons of oil per ton and the lower zone possibly contains an additional 300 feet of shale averaging 30 gallons of oil per ton with a total in-place resource of 800,000 to 900,000 barrels per acre. Nahcolite is present in pods in the lower part of the lower zone and may be bedded in the northwest part of the tract. Oil shale containing dawsonite in varying amounts may attain a thickness of 300 feet in parts of the area. A 600-ft-thick unit that starts in the lower part of the Mahogany zone and extends downward into the lower zone formerly contained saline minerals that have been leached by groundwater. The voids created by leaching are filled with water varying in quality from potable in the upper part of the leached zone to moderately saline in the lower part. No oil or gas has been found in Tract C-b; however, commercially significant amounts of gas and small amounts of oil have been produced from the Douglas Creek Member of the Green River Formation, and the Wasatch, Fort Union, and Mesaverde Formations elsewhere in the Piceance Creek Basin. The Fort Union and Mesaverde Formations being considered in the Rio Blanco gas stimulation proposal underlie the entire tract at a depth of 2,000 or more feet below the base of the oil shale. Overburden on the Mahogany zone varies from a minimum of 800 feet to a maximum of 1,250 feet and averages 1,100 feet. The rocks strike to the east or northeast in most of the tract. The axis of a syncline is subparallel to the northern boundary of the tract, and north of the axis the strike of the rocks is to the northwest. Dip in most of the area is north to north-northwest at the rate of 150 feet per mile. Along the northern boundary the dip is southwest at the rate of 200 feet per mile.


Northwest
Southeast
7000'
6000'
5000'
7000'
6000'
5000'
Mahogany Zone (Rich oil shale)
Leached zone
WASATCH FORMATION
Verigated claystone and lenticular sandstone
U D
Sandstone, Siltstone, and marlstone
marlstone, oil shale, and thin sandstone and siltstone beds
GREEN RIVER FORMATION
oil shale and dawsonite
oil shale, nahcolite, and dawsonite
clay, shale, and sandstone
1000
500
0
1000
2000
feet

Generalized Section for Tract C-a.



Generalized section for tract C-b

2.c.2 -- Summary of Geology and Mineral Resources of the Eastern Uinta Basin

The nominated tracts are located in the eastern part of the Uinta Basin--a sedimentary, structural, and topographic basin. The area of the present topographic basin was occupied by a large lake during much of Eocene time. In middle Eocene time the deepest part of the lake was a depositional trough in which organic material was deposited that now makes up the richest and thickest oil-shale beds. During this same period of time, coarser nonorganic material was deposited in shallower water near the margin of the lake. The tracts lie in or near the former position of the depositional trough. The axis of the structural basin has an arcuate trace and throughout most of its extent lies near the south flank of the Uinta Mountains and several miles north of the tracts.

Stratigraphy

Surface rocks within the tracts are, for the most part, beds of the Uinta Formation that are composed of brown and gray sandstone, siltstone, and shale overlying the Green River Formation. The Green River Formation is exposed in a relatively small part of the total area of the tracts.

The upper part of the Green River Formation is composed chiefly of light-gray to dark-gray beds of marlstone, low-grade oil shale, and some tuff. Saline minerals are found in these upper layers in the form of very thin lenses or beds and small pods. Underlying the upper sequence is a series of dark-gray oil-shale beds that occurs in and adjacent to the Mahogany zone and can be considered as a middle sequence of the Green River Formation. That part of the formation below the Mahogany zone is composed principally of interbedded brown and gray sandstone,

shale, and limestone. It also contains some oil shale, the richer beds occurring in the upper part.

Structure

The structure of the area encompassing the tracts is quite simple. The oil-shale beds are inclined northward and northwestward, with dips ranging from 2° to 4°. Structural closure or reverse dip does not occur along any of the beds. There are no significant faults within the tracts but the Green River Formation is broken by a system of closely spaced fractures, some of which show a minor amount of displacement. The fractures, or joints, are most conspicuous in the marlstone and low-grade oil shale.

Paleontology

The remains of fossilized vertebrate animals have been found at several localities in the Uinta Formation of the Uinta Basin. Such fossils may be present in the tracts, although there is no record thus far of their discovery. The upper, most fossiliferous, part of the Uinta Formation (Uinta B and Uinta C) has been eroded from much of nominated tracts 1, 2, 4, and 5, leaving only Uinta A, which vertebrate paleontologists consider as essentially barren of significant vertebrate fossils. Tract 3 is underlain by Uinta A, Uinta B, and the lower part of Uinta C, and there is, therefore, a greater possibility that it contains vertebrate fossils. Carbonized plant remains have been found in the Uinta Formation. Certain beds in tracts 4 and 5 are known to contain fossil plants and these beds probably contain fossil plants in tracts 1 and 2. Lateral changes preclude the possibility that the same beds would

yield fossil leaves in tract 3, but other strata may have been deposited in an environment that preserved plant remains. The Green River Formation also yields abundant macrofossils such as gastropods, pelecypods, ostracods, fish scales, and fossil microorganisms such as spores, pollen, and algae.

Resources

Oil shale is potentially the most valuable mineral resource in the rocks of the eastern Uinta Basin. It has been estimated that in the Uinta Basin there are 80 billion barrels of shale oil in oil shale that yields an average of 25 gallons of oil per ton. A very large percentage of the oil-shale resources of the Uinta Basin are in the eastern half. Other mineral resources in the eastern Uinta Basin are fluid, semisolid, and solid hydrocarbons. Several fields yield oil and gas, and gilsonite, a solid hydrocarbon, is mined near Bonanza, Utah. The extensive asphaltic sandstone deposits of the eastern Uinta Basin are not being developed at present but should be regarded as a potential source of oil. Commonly the asphaltic material is found in a rock sequence, the top of which is 20 to 100 feet below the Mahogany zone. Nahcolite ($NaHCO_3$) occurs as very thin lenses or beds and small pods in the upper part of the Green River Formation, mostly in an interval extending from 300 to 600 feet above the Mahogany zone. The quantity is probably not great enough to allow profitable recovery. There are minor occurrences of uranium in the lower part of the Uinta Formation and the upper part of the Green River Formation of the eastern Uinta Basin. None has been noted in the tracts.

Tract Selection

Tracts U-a and U-b are believed to have the most favorable conditions for beginning a successful oil-shale operation in Utah. Core-hole data indicate that the thickness of the oil-shale sequence in tract U-a and tract U-b is slightly greater than in nominated tracts 1 and 3. Overburden above the oil-shale sequence is least in tract U-b and is somewhat greater in tract U-a than in tract 1. The overburden in tract 3 is much greater than in the other tracts. The ratio of overburden to oil shale in tract 3 makes it suited for in situ development but not for mining.

Geology of Selected Tract U-a

Stratigraphy

All of the rocks exposed in tract U-a are within the Uinta Formation and most of these rocks are in the lowermost subdivision of the formation, Uinta A. The outcrops are chiefly brown and gray ledge forming sandstone, and siltstone and gray and greenish-gray slope forming marlstone and shale. Uinta A rests conformably on the Green River Formation.

The interval between the base of the Uinta and the top of the principal oil-shale sequence is about 500 feet thick and is composed of gray marlstone and low-grade oil shale, and thin beds of dark-gray oil shale. The upper 200 feet contains some very thin lenses or beds and small pods of nahcolite. The Mahogany zone in tract U-a is roughly 70 to 100 feet thick and is bounded at top and bottom by sequences that are essentially barren of oil shale. Below this, there is an interval containing gray and brown marlstone, siltstone, and thin beds of dard-gray oil shale. The interval has a maximum thickness of about 400 feet. Southward across the tract it is replaced by sandstone and shale. The remainder of the Green River Formation contains little oil shale and consists chiefly of

brown and gray sandstone, siltstone, algal limestone, oolitic limestone, ostracodal limestone, and flaky shale.

Structure

The strata in tract U-a dip gently northwestward at about 2°. There are no significant surface faults but some evidence of a joint system can be seen on the outcrop and on aerial photographs. Jointing is probably more pronounced in the underlying Green River Formation.

Resources

Oil shale thicknesses in tract U-a are unknown because there has been no core drilling in the tract. It is estimated that the oil-shale sequence that averages 25 gallons of shale oil per ton is about 80 to 100 feet thick. This is based on extrapolation of oil-yield assay data from core holes outside the tract and mechanical logs from exploratory wells within the tract. Overburden above the Mahogany zone ranges from 550 feet to 1,225 feet and the average is approximately 850 feet.

The Southman Canyon field, which has produced gas from the Wasatch Formation and gas and some oil from the Mesaverde Formation, lies partially in tract U-a. Although the Uinta Formation produces gas in some parts of the Uinta Basin, it is very unlikely that it contains gas in tract U-a.

Nahcolite is probably present in the tract as very thin lenses or beds and small pods. There are no reports of significant amounts of bituminous sandstone in the tract, surface or subsurface, and no obvious gilsonite veins.

Geology of Tract U-b

Stratigraphy

Most of the strata exposed in these tracts are within the lowermost 750 feet of the Uinta Formation. The remainder are in the upper 200 feet of the Green River Formation, outcropping mainly along Evacuation Creek. The Uinta outcrops are chiefly brown and gray ledge forming sandstone and siltstone and gray and greenish-gray slope forming shale and marlstone.

The stratigraphic interval between the base of the Uinta Formation and the principal oil-shale sequence in the Green River Formation is approximately 500 feet thick and is composed of gray marlstone and low-grade oil shale and thin beds of dark-gray oil shale. The upper 200 feet contains some very thin lenses or beds and small pods of nahcolite. The Mahogany zone in tract U-b is roughly 95 feet thick and is bounded at top and bottom by sequences that are essentially barren of oil shale. Below this, there is an interval approximately 400 feet thick containing gray and brown marlstone, siltstone, and thin beds of dark-gray oil shale. The remainder of the Green River Formation contains little oil shale and is composed chiefly of brown and gray sandstone, siltstone, algal limestone, oolitic limestone, ostracodal limestone, and flaky shale.

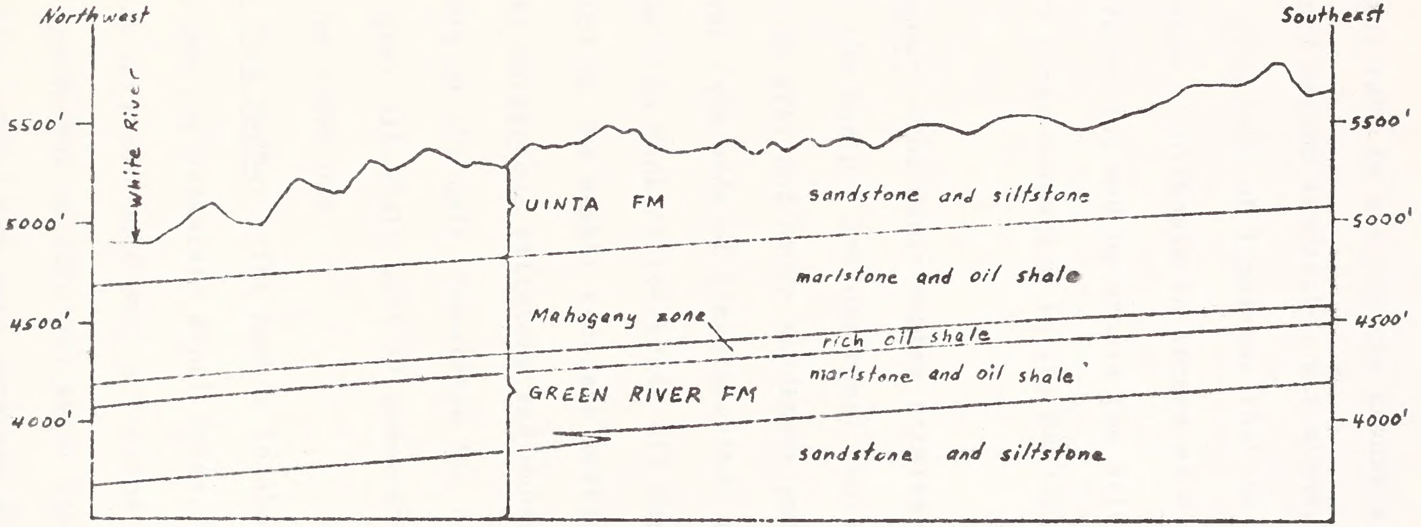
Structure

The strata in tract U-b dip gently westward to northwestward at 2° to 4°. There are no significant surface faults but there is much evidence of jointing, especially in the beds of the upper Green River Formation.

Resources

Assayed samples from core holes in tract U-b show the maximum thickness of oil shale yielding an average of 25 gallons of oil per ton to be approximately 99 feet. Overburden above the principal oil-shale beds ranges from 300 to 1,250 feet and the average is about 700 feet.

No oil or gas has been discovered in the tract and there is no known occurrence of significant amounts of bitumen in sandstone. One narrow gilsonite vein (less than 2 inches wide) outcrops in the west-central part of the tracts. Hancolite occurs as very thin lenses or bed and small pods in the upper part of the Green River Formation.



Representative section for tracts U-A and U-B

2.c.3 General Summary of the Geology and Mineral Resources in the Washakie Basin

Stratigraphy

The surface rock in most of the Washakie basin consists mainly of gray, green, and maroon sandstone, siltstone, and mudstone, tuffaceous in part, with thin beds of limestone that in places are algal. This unit that attains a thickness in excess of 2,400 feet is called by some the Washakie Formation and by others the Bridger and Uinta Formations.

The Green River Formation in the Washakie basin is divided into four units:

Laney Member.--The Laney Member attains a thickness of more than 1,300 feet in the basin. The uppermost two-thirds of the member consists in great part of gray and brown sandstone and siltstone, in part tuffaceous, and thin beds of limestone that in places are algal. There are also a few thin beds of low-grade oil shale in the lower part. The lower one-third of the member consists mostly of oil shale of varying value. A buff to gray tuffaceous siltstone and mudstone bed 50 to 60 feet thick, near the middle of the unit, separates the oil-shale sequence into two zones. The upper oil-shale unit is somewhat thicker and in general richer than the lower one.

Wilkins Peak Member.--The member is about 400 feet thick and may be divided into two approximately equal units. The upper unit consists mainly of gray or brown mudstone, siltstone, or sandstone, and minor amounts of thin-bedded oolitic and algal limestone and thin beds of low-grade oil shale. The lower unit consists almost entirely of low-grade oil shale with some beds of moderately rich oil shale, algal limestone,

and siltstone. The Wilkins Peak Member is separated from the Laney Member by more than 1,500 feet of varicolored mudstone, sandstone, and siltstone in the Cathedral Bluffs Tongue of the Wasatch Formation.

Tipton Member.--The Tipton Member immediately underlies the Wilkins Peak Member, is about 200 feet thick, and consists almost entirely of low-grade to moderately rich oil-shale with a few thin algal limestone and siltstone beds. The oil shale in the upper half is considerably richer than that in the lower half.

Luman Tongue.--The Luman Tongue is the lowermost unit in the Green River Formation. It is about 300 feet thick and the upper half consists almost entirely of low-grade oil shale with a few thin-bedded limestones. The lower half consists of interbedded siltstone, sandstone, mudstone, low-grade oil shale, thin moderately rich oil shale, fossiliferous limestone, carbonaceous shale, and coal. The Luman is separated from the Tipton by about 200 feet of interbedded siltstone, sandstone, mudstone, low-grade oil shale, thin moderately rich oil shale, fossiliferous limestone, carbonaceous shale, and coal in the Niland Tongue of the Wasatch Formation.

PALEONTOLOGY

Megafossils.--These may be grouped in several general categories--vertebrates, plant remains, and mollusca.

Vertebrates.--Easily identifiable mammal remains have been collected by the Field Museum of Natural History in and around the Washakie basin. These localities are in rocks that overlie, underlie, or intertongue with, but are not within, the Green River Formation. One of these localities is in the northeast corner of nominated tract 1. Perhaps the best known

fossil fish locality in Wyoming is in rocks of the Green River Formation in the Fossil basin; and papery low-grade oil shale in the Laney Member of the Green River Formation in the Washakie basin also contains well-preserved remains of small fish.

Plant remains.--Several leaf localities have been sampled in the Laney Member and the Luman Tongue of the Green River Formation. Poorly preserved leaves and fragments of carbonized remains of twigs and branches are found in the oil shale of all members of the Green River Formation. Fossilized wood occurs at several horizons in the rocks overlying the Green River Formation.

Molluscs.--Both gastropods and pelecypods are found in great abundance in thin beds in all units of the Green River Formation. In most places the base of the Tipton Member is marked by a coquina of high spired gastropods. Microfossils include ostracods and spores and pollen.

Ostracoda.--Ostracods are usually associated with thin limestone beds that contain pelecypods and gastropods but occasionally form ostracod coquinas in all members of the Green River Formation.

Spore, pollen.--These constitute a part of the organic fraction of the oil shale in the various members of the Green River Formation.

Algae.--Algae is found in the organic fraction in the oil shale and also in places forms large biohermal mounds in all Members of the Green River Formation.

STRUCTURE

Folds.--The Washakie basin is essentially a large northeast-trending syncline. The main synclinal feature is modified in places by subsidiary structures.

Faults.--The center of the Washakie basin is essentially fault free. Intensity of faulting is greatest along the southern margin of the basin. In this area the southernmost faults trend west parallel to Cherokee Ridge, a structural high that bounds the Washakie basin on the south. North of the west-trending faults are a series of northwest-trending normal faults as much as 10 miles in length that extend from the Wasatch Formation outcropping on the southern margin into the lowermost part of the rock sequence overlying the Green River Formation that outcrops near the center of the basin. The west margin of the basin is less heavily faulted; however, there are some north to northwest-trending normal faults along the west margin that are less than 6 miles in length. The northwestern, northern, and northeastern parts of the basin are essentially fault free.

MINERAL RESOURCES

Oil shale.--Recently the U.S. Bureau of Mines drilled two core holes near the western margin of the Washakie basin. This is the only core assay information publicly available from the Washakie basin and was deemed to be insufficient for a reliable estimate of the oil-shale resources of the entire Washakie basin.

Other minerals.--Thus far, minerals associated with the oil-shale deposits in other basins have not been found with the oil shales in the Washakie basin.

No oil or gas has been found on either tract W-a or W-b. However, both oil and gas, in commercial quantities, has been produced from the Wasatch, Fort Union, and Mesaverde Formations in fields surrounding the Washakie basin. These producing formations underlie both of these tracts. The producing zones in the Fort Union and Mesaverde Formations are several thousand feet below the lowermost oil shales in the Green River Formation.

GEOLOGY OF NOMINATED TRACTS

The three nominated tracts are adjacent to one another along the western margin of the Washakie basin. The geology varies slightly over relatively large areas in the Washakie basin; therefore, the geology of all three tracts will be described as one.

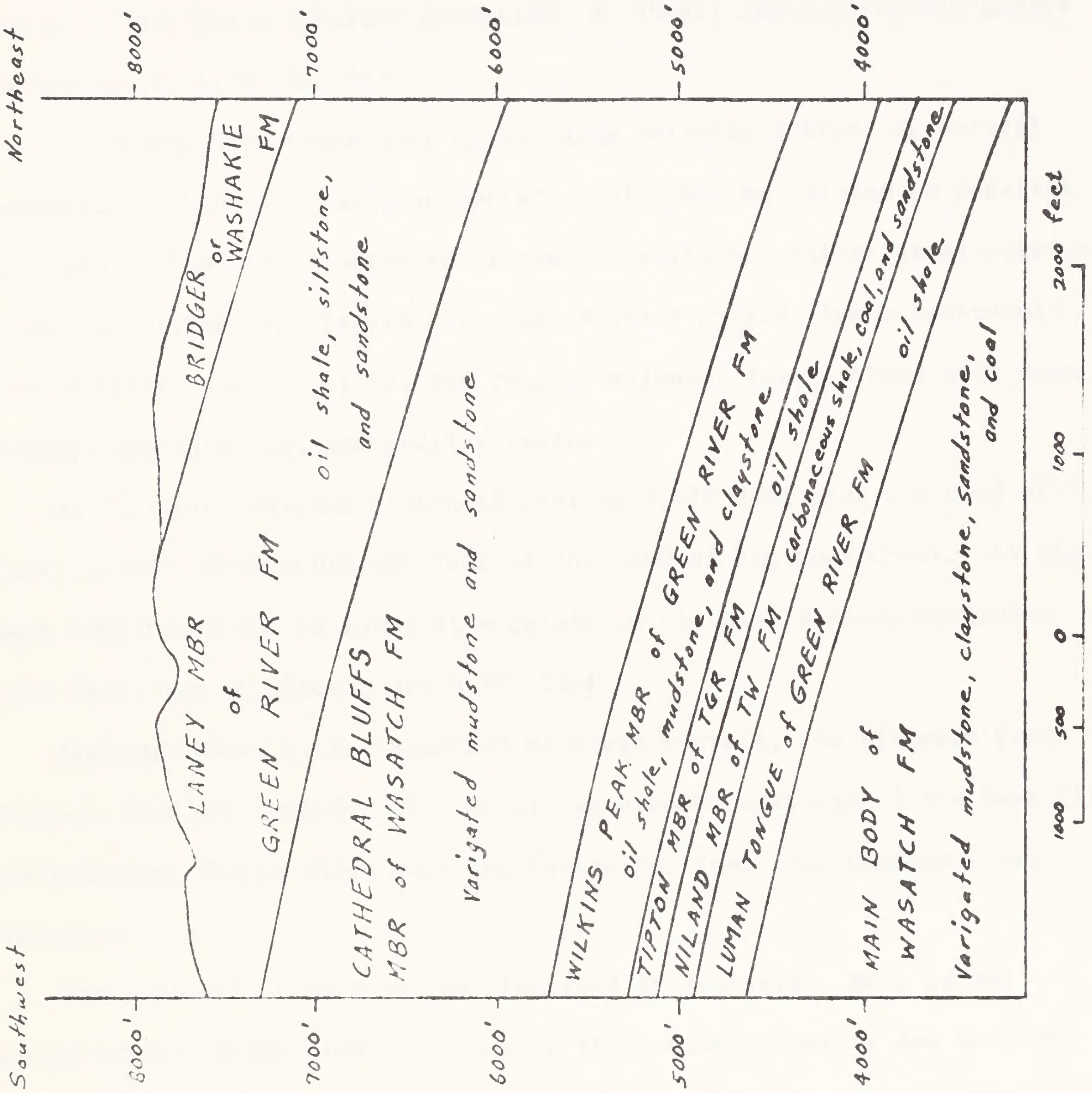
U.S. Bureau of Mines Washakie basin Core Hole 1 is in the northern part of tract W-a and assay values of the Laney, Wilkins Peak, and Tipton Members in the core are assumed to be representative of the value of these members underlying all three tracts. U.S. Bureau of Mines Washakie basin Core Hole 1A was drilled 1½ miles west of tract W-a and assays from this core were considered to be representative of the value of the Luman Tongue of the Green River Formation underlying the tracts.

There is no oil shale underlying the tracts that averages 30 or more gallons per ton in thicknesses greater than 15 feet. However, in the lower half of the oil-shale bearing part of the Laney, a zone between 15 and 20 feet thick averages more than 25 gallons of oil per ton containing an in-place resource of about 30,000 barrels per acre. Two zones in the Laney Member average 15 gallons of oil per ton: one about 145 feet thick in the upper part of the oil-shale bearing segment of the Laney, and the other about 85 feet thick in the lower part of the oil-shale bearing segment of the Laney. These two units have a combined in-place resource of about 260,000 barrels per acre. The uppermost 40 feet of what has been called Wilkins Peak averages more than 15 gallons of oil per ton and has an in-place resource of approximately 45,000 barrels per acre. The upper 30 feet of what has been called tipton averages more than 15 gallons of oil per ton and has an in-place resource of approximately 35,000 barrels per acre.

There is no overburden on the oil-shale segment of the Laney Member near the western margin of the tracts. The overburden increases rapidly to the east a maximum of 2,400 feet and an average overburden of 600 feet. The minimum overburden on the top of the Wilkins Peak is 900 feet, the average 2,200 feet, and the maximum 4,900 feet. The minimum overburden on the Tipton is 1,200 feet, the maximum 5,200 feet, and the average 2,500 feet. The minimum overburden on the top of the Luman is 1,600 feet, the maximum 5,600 feet, and the average 2,900 feet.

Rocks in the area strike to the northwest. Dips are all to the northeast at a rate varying from 8° to 10° on the west to more than 20° on the east.

Two north-trending normal faults less than a mile long displace the oil shale by as much as 100 feet. The west side is downfaulted.


Southwest
Northeast
8000'
7000'
6000'
5000'
4000'
LANEY MBR of GREEN RIVER FM
BRIDGER or WASHAKIE FM
oil shale, siltstone, and sandstone
CATHEDRAL BLUFFS MBR of WASATCH FM
Varigated mudstone and sandstone
WILKINS PEAK MBR of GREEN RIVER FM
oil shale, mudstone, and claystone
TIPTON MBR of TGR FM
oil shale
NILAND MBR of TW FM
carbonaceous shale, coal, and sandstone
LUMAN TONGUE of GREEN RIVER FM
oil shale
MAIN BODY of WASATCH FM
Varigated mudstone, claystone, sandstone, and coal
1000
500
0
1000
2000 feet

Generalized section for tracts W-a and W-b

2.d.1 -- Water Resources Information (Piceance Creek Basin of Colorado)

Water resources of the basin are described in the two U.S. Geological survey reports (Coffin and others, 1968 and 1971), and are summarized in two other recent reports on mineral development of the basin (Colorado Governor's Oil Shale Advisory Committee, p. 31-42; and U.S. Atomic Energy Commission, 1971, p. A15-A27).

The distinctive topography of the area reflects a broad structural depression etched by a jointing pattern, which may be related to parallel north and northeasterly oriented ridges and valleys. Differential erosion of the underlying rock layers has created sharp ridges, low to moderately rounded hills, abrupt cliffs, and rugged badlands, interspersed with open valleys, upland parks, and smaller basins.

On the west, maximum altitudes include 8,420 feet near the head of Black Sulphur Creek and 8,685 feet at the head of Big Duck Creek. At the south edge there are at least five points on the Roan Plateau exceeding 8,400 feet, two of which reach 8,700 feet.

Although there is an abundance of rough terrain, the Piceance Creek drainage does not include the dramatic escarpment features of the Book Cliffs and Cathedral Bluffs which mark the Parachute, Roan, and Douglas Creek drainages.

The region's climate can be described as semiarid. Mean annual precipitation varies from 12 inches in the northwest corner and at lower elevations to 25 inches along the high ridges in the south. Slightly less than one-half the precipitation occurs as snow during the months of December to April, with small amounts of rain and snow in April, May, and early June. During the late summer, thunderstorms occur in a pattern

starting in the vicinity of Douglas Creek Pass and the Cathedral Bluffs, then proceeding easterly and northeasterly across Piceance Creek, producing cloudbursts and highly eroding flash floods.

The region is subject to extremes in temperature due to the wide variations in elevation and exposure. During the past 5 years, U.S. Bureau of Land Management personnel have noted temperatures ranging from 100°F in summer to 40°F below zero in the winter. Frost-free days vary from 120 near the White River to less than 50 at the highest elevations. Snow occurs over the entire area, usually starting in October. At lower elevations the snow melts early in the year; by late fall it will remain on the ground, except on windswept ridges.

Streamflow is small, fully developed, and dependent upon snowmelt, other runoff, and springs. Water in the Piceance Creek and its tributaries ranges from fresh to slightly saline (1,000 to 3,000 mg/l dissolved solids). Groundwater can be developed from the alluvium by wells which may produce as much as 2,000 gpm (gallons per minute), but such wells would quickly deplete streamflow and their development surely would be limited by the Colorado State Engineer. Water can be developed from the leached zone of the Green River Formation by wells yielding as much as 1,000 gpm, but this water contains dissolved-solids concentrations of from about 1,000 to 60,000 mg/l (milligrams per liter), and pumping from the leached zone will reduce the artesian pressure in the aquifer and reduce streamflow in the basin. Pumping from the upper part of the leached zone may cause undesirable upward salt-water movement. However, large ground-water withdrawals may be necessary to drain mines. The water produced from mines probably can be used to partly supply the demands for

oil shale processing. According to the U. S. Bureau of Reclamation (written commun., 1972), the proposed Yellow Jacket and Rio Blanco or Sweetwater projects in the White River basin, upstream from Piceance Creek, could yield as much as 165,000 acre-feet per year when and if completed. Over 200,000 acre-feet per year might be developed in the Colorado River basin for use in the Piceance area.

Tract C-a is located in the west-central part of the upper part of the Corral Gulch tributary to Ryan Gulch, a direct tributary to Piceance Creek. Boxelder Gulch, a small tributary to Corral Gulch, flows diagonally through the tract from southwest to northeast and joins Coal Gulch near the northeast corner of the tract. Few data are available on the flow of these small tributaries, but owing to their location high toward the rim of the basin, it can be assumed that most will not sustain streamflow except during periods of snowmelt and runoff from thunderstorms.

Significant quantities of ground water, perhaps more than 100 gallons per minute, can be pumped from the alluvium along the creek. Water supply from the upper part of the leached zone is also a possibility. Water in this zone is slightly saline -- the dissolved-solids concentration ranges from 1,000 to 2,000 mg/l. Data suggest that water in the lower part of the leached zone contains considerably more dissolved solids, and that transmissivity of the lower part generally is greater than that of the upper part of the leached zone. Artesian pressure brings the static water level to within 300 feet or less of the surface, and a possibility of flowing wells exists near the northeast corner of the tract.

Tract C-b is located from 1 to 6 miles south of Piceance Creek in the region drained by Cottonwood Gulch, Scandard Gulch, Sorghum Gulch, and the West Fork of Stewart Gulch. It is in a position where a fresh water supply might be developed in the alluvium along Piceance Creek, or a supply might be diverted from the creek. However, during periods of low flow the dissolved-solids concentration of Piceance Creek becomes too high (in excess of 5,000 mg/l) for most uses, and in addition, prior water rights and Colorado water law would limit development and use of either the shallow ground water or the surface water of Piceance Creek. The problem of prior water rights might be overcome by the oil shale industry if it was to purchase water rights from senior holders, but this would not eliminate the water-quality problem.

Few specific data are available for Tract C-b, but owing to its location near the center of the basin, it is assumed that good quality water cannot be developed from the leached zone of the Green River Formation. Data from a well located in the southwestern part of the tract show that some relatively fresh water (dissolved-solids concentration less than 1,000 mg/l) might be available in the upper part of the leached zone. However, water at greater depths in the leached zone is too salty for most uses.

2.d.2 -- Water Resources Information (Uinta basin, Utah)

Selected Tracts U-a and -b adjoin each other; therefore, discussion of the hydrology of the Uinta basin will be limited to the region of the tracts. Both tracts are located south of the White River within one mile or so of the stream. Mean flow of the river in this reach is about 650 cfs (cubic feet per second), and the weighted average dissolved-solids concentration is slightly less than 500 mg/l.

Ground water occurs above and in the oil shale, but data are not available to judge the possible yields of wells in the aquifers, or the quality of water that might be developed. One well record in the vicinity of the tracts reported "fresh" water at a depth of 600 feet. Ground water at greater depth, in and adjacent to the oil shale, can be expected to contain from 1,000 to 3,000 mg/1 of dissolved solids. The water probably moves through the tracts in a northwesterly direction, so that extensive pumping on the tracts probably will affect the flow of the White River.

2.d.3. -- Water Resources Information (Kinney Rim, Wyoming)

This region is part of an intermontane desert basin in south-central Wyoming. It ranges in elevation from 7,800 to 8,400 feet, with a stark and windswept landscape, sparse vegetation of sagebrush and prairie grasses, and annual precipitation of less than 10 inches. Ground water hydrology of the region is cursorily described in a report by Welder and McGreevy (1966).

Tracts W-a and W-b adjoin each other and are located near the Kinney Rim escarpment in the region drained to the south by Alkali Creek and Shell Creek. The Laney Shale Member of the Green River Formation is the principal oil shale bearing formation in this region, but few data are available to appraise the ground-water hydrology of the site. Water occurs above, below, and probably in the shale, and deep water is under artesian pressure. Permeabilities of the aquifers probably are low.

Chemical quality of the ground water ranges from good to poor. Water having a dissolved-solids concentration of less than 1,000 mg/1 is known to exist in a shallow aquifer, but no data are available to estimate how

much might be produced by a well in this formation.

Streamflow is intermittent in the area, and is dependent largely upon snowmelt and runoff immediately after storms, and small amounts of ground water inflow from a few springs.

2.e -- Wildlife

The inter-mountain oil shale province, comprised of portions of Colorado, Utah, and Wyoming, consists of a sparsely settled, semi-arid to arid region, drained by the upper basin tributaries of the Colorado River. Found within this oil shale area is a unique ecological combination of vegetative, climatic, physiographic, and cultural features which result in favorable conditions and habitats for a broad range of wildlife species, of which the mule deer has greatest economic and recreational significance.

In addition to the mule deer there are six other species of big game occupying the oil shale area, 3 species of small game, 27 species of migratory waterfowl and shorebirds, 6 species of upland game birds, 5 species of furbearers, 21 species of non-game animals, 200 species of non-game birds, and 24 species of raptors. Several wild horse herds, comprising about 500 animals range over the area.

Of primary significance far beyond the total numbers involved, is the known or suspected presence of several of the rare or endangered bird and mammal species which have attracted national attention during recent years.

The broad expanse of sparsely settled plateaus, plains and canyons situated in northwest Colorado, northeast Utah, and southwest Wyoming is occupied on an intermittent basis, and is likely utilized as nesting habitat by an occasional pair of the endangered Southern Bald Eagle (Haliaeetus leucocephalus); and the American Peregrine Falcon (Falco peregrinus anatum); as well as for the rare Prairie Falcon (Falco mexicanus).

The recent field sighting of a Black-footed ferret (Mustela nigripes) within the Uinta Basin near Vernal, Utah, strengthens the belief that this endangered species may persist in small numbers throughout suitable portions of the oil shale region. In addition, three species of fish including the endangered Colorado River Squawfish (Ptychocheilus lucius), as well as the unique Humpback and Bluehead sucker species, are currently found.

The three state oil shale region contains extensive habitat areas which are utilized on a yearlong basis by a considerable number of mountain lion (Felis concolor) and Golden Eagle (Aquila chrysaetos). Although these species are not considered rare or endangered, a large portion of the public has been extremely interested in their future welfare.

2.e.1 -- Wildlife (Colorado)

Colorado - Piceance Creek Basin

For many years the 800,000 acre Piceance Creek Basin has been recognized as Colorado's most important mule deer range. It serves as the principal wintering ground for the nationally famous migratory White River herd.

Survey reports reveal the basin provides a major portion of the critical winter forage needs for up to 15-20% of the total State deer population. During the 1960-69 period sportsmen took an average 6,000 deer annually from within the basin, in some years accounting for approximately 10% of the total State deer harvest.

For decades the wildlife resources in the Piceance Creek Basin have been an important recreational source of both local and national significance, providing benefits for area ranchers, businessmen, recreationists, and

the general economy of surrounding communities. During the 1960-69 period, deer hunting alone has generated an average of 40,000 recreational days use annually.

The Colorado Game, Fish and Parks Division has active fish and wildlife management programs in the Piceance Creek Basin. The agency has acquired surface fee-title ownership to over 26,000 acres, together with cooperative resource management control over approximately 150,000 acres of key habitat. It has conducted a continuing series of land-use investigations, and promoted development of a selected road system for recreational use.

Although the mule deer is of prime importance in Piceance Basin, other wildlife species contribute to its aesthetic and recreational potential. Populations of ducks, doves, chukars, grouse, pheasants, rabbits, lion and miscellaneous non-game species are normally present in fair numbers. Seasonal use by limited numbers of bear, elk, and wild horses is not uncommon.

Fishery resources within the Basin are generally limited. A number of small headwater streams provide some opportunity for sport fishing under semi-wilderness conditions, and several downstream ponds and reservoirs also contribute to the area's overall recreational potential.

(1) Colorado Tract C-a

Test-lease Tract C-a, located in T's 1 and 2S, R99W, within Corral-Boxelder Gulch area of Yellow Creek Drainage, lies at a mean elevation of 7,000 feet. Existing vegetation consists of three major types--pinyon-juniper, sagebrush, and mt. browse, containing a moderately dense understory cover of various grass and forb species, developing under a mean annual precipitation of approximately 16 inches.

A wide variety of wildlife species utilizing the site on a seasonal or yearlong basis include mule deer, wild horses, mountain lion, coyote, bobcat, rabbits, hawks, eagles, sage grouse and doves, plus numerous small bird and mammal species of aesthetic and ecological value. The area lying at a mean elevation of 7,000 feet, has very significant value for winter, as well as spring fall deer range, and constitutes one of the heaviest wild horse use areas within the Piceance Creek Basin.

Colorado test-lease Tract C-a is served by a series of undeveloped roads and trails, situated approximately 16 miles from a surfaced highway system on Piceance Creek. The tract lies in the heart of a relatively remote, undisturbed habitat area managed by the Colorado Division of Game, Fish and Parks for the primary benefit of wildlife species and a broad spectrum of recreational users. In addition, the Shields-Caldwell Hunting Camp, a commercial establishment headquartered within the tract boundaries, provides recreational access and services to a considerable number of sportsmen annually.

A large portion of the mule deer population utilizing high elevation summer range on the Cathedral Bluffs-Roan Divide area, moves to historic winter range at lower elevation within the Piceance Basin. Test lease Tract C-a lies within the intermediate winter-use range zone, and bisects important deer migration routes used in their seasonal movements.

Existing land-use programs on Colorado Tract C-a, involve the coordinated management of domestic livestock and wildlife resources on a continuing, sustained production basis. Some additional disturbance related to future oil, gas, or mineral development may be anticipated, however, in the absence of proposed test-lease activities it can be assumed that current

levels of wildlife productivity, species distribution, and recreational use can be maintained on a continuing and sustained-yield basis.

(2) Colorado Tract C-b

Test-lease Tract C-b is located in T3S, R96W, near mouth of Stewart and Scandard Gulch area of Piceance Creek drainage. It lies at a mean elevation of 6,800 feet. Existing vegetation consists of Pinyon-Juniper, mountain browse, and sagebrush, with an understory of various forb and grass species, developing under an average precipitation of 16 inches annually.

A diverse association of wildlife species utilizes the site on a seasonal or yearlong basis, including mule deer, elk, mountain lion, coyote, bobcat, rabbits, grouse, doves, and raptors, as well as numerous other small bird and mammal species. This tract, lying within the intermediate range zone averaging 6,800 feet, receives some intermittent use by wintering herds of deer and elk. Some suitable eagle nesting habitat exists within and adjacent to the proposed site, however, verified use and productivity figures are currently lacking.

Test-lease Tract C-b lies immediately adjacent to important surfaced highway on Piceance Creek, and the unimproved roads paralleling west Stewart and Scandard Gulches. As a result, the tract is currently subject to the disruptive impact of rather high vehicular traffic flows, as well as the effects of intensive livestock operations conducted on several large adjacent Piceance Valley headquarters ranches. Although large portions of the tract contain significant wildlife resource values, game harvest and general recreational use is limited through current actions of controlling landowners. Recreation oriented activities, primarily sport

hunting, account for several hundred man-days use annually.

Current land-use objectives related to Tract C-b acreage involve joint domestic livestock grazing as well as optimum production by indigenous wildlife species. Populations of a number of birds and mammals designated as game species, as well as various carnivores, are managed on a sustained yield basis, consistent with food and other habitat requirements. It may be anticipated that currently existing associations of wildlife species and their annual productivity can be maintained on a continuing, sustained basis, whereas potential for increased levels of recreational use may be expanded through planned acquisition of expanded public access facilities.

2.e.2 -- Wildlife (Utah)

The major topographic feature encompassing oil shale resources in Utah is the Uinta Basin. The major drainages in the vicinity of rich shale deposits consist of the Green River and White River systems which pass through deep escarpments. Geologic processes have created rugged, dissected terrain that is difficult to traverse, resulting in land forms of great scenic beauty, remaining in a state approaching primitive isolation.

The Uinta Basin oil shale area is a unique ecological combination of vegetative, climatic, physiographic and cultural conditions which constitute ideal fish and wildlife habitat. Although the mule deer is regarded as the most important of the species represented, many forms of game as well as non-game birds and mammals are present in significant numbers. In their natural association they constitute a major aesthetic, recreational and economic resource.

Oil shale deposits in Utah encompass more than 1-1/4 million acres of important mule deer range, of which 250,000 acres are considered critical as winter feeding areas. An average annual harvest of 8,000 deer within the Basin reflects the recreational opportunities and economic potentials generated by wildlife resources on relatively undisturbed natural range areas.

Headwater drainages throughout the Uinta Basin contain considerable trout fishing potential. Heavy siltation and accompanying degradation of water qualities has created a generally depleted fish environment in lower reaches of the major river systems. The most common food fish of value in the Green and White River systems is the catfish, however, three species of rare and unique fish, the Squawfish, Humpback sucker, and Bluehead sucker, are currently found only in the Green River.

(1) Utah Tracts U-a and -b

Test lease Tracts U-a, situated in T10S R24E (Lower Asphalt Wash) and Tract U-b, located in T10S, R's 24 and 25E (Lower Evacuation Creek), lie immediately south of the White River at a mean elevation approximately 5, 600 feet. Major vegetation developing under annual precipitation of less than 10 inches consists of Pinyon-Juniper, salt desert shrub (Atroplex spp.) sagebrush, in addition to a sparse understory cover of mixed forbs and grasses.

Proposed test-lease sites U-a and U-b contain a healthy association of wildlife species, including mule deer, mountain lion, coyote, bobcat, rabbit, chukar partridge, dove, and raptors as well as numerous small bird and mammal species.

The Utah tracts contain habitat of specific value as deer winter range and sustain approximately a hundred hunter-days use by sportsmen annually. Important eagle (bald and golden) nesting and roosting sites are present along drainage escarpments, while the general area is occasionally frequented by the rare prairie falcon. Waterfowl aquatic furbearers, and various species of sport fish utilize the adjacent White River system.

In addition to identified wildlife habitat values, the proposed Utah test-lease sites possess unique recreational value inherent in their relatively remote isolation from commercial development. Although the eastern portion of the lease unit is bisected by an unimproved county highway and a gilsonite transmission pipeline, the general area retains a basically primitive quality. The geologically dissected and eroded terrain has a scenic beauty enjoyed by many recreationists.

2.e.3 Wildlife (Wyoming)

The Green River Basin oil shale lands possess significant fish and wildlife values. High quality game habitats consisting of varied associations of browse, forb and grass species provide forage requirements for significant populations of deer, elk and antelope. In addition the area contains thriving populations of blue grouse, sage grouse, chukars, doves, rabbits, coyotes, bobcats, as well as various species of waterfowl, raptors, and the numerous other small bird and mammal forms expected in an ecologically healthy high-desert range area. Wild horses are quite numerous throughout general range areas, and a number of threatened species, including the mountain lion, bald eagle and golden eagle are dependent upon habitat within the Green River Basin.

Wyoming's Green River Basin consists of one of the State's most important antelope habitat areas, supporting a high density population. Approximately 1,500 hunters use the area annually, experiencing a harvest success averaging 90%. In addition, the Basin ranks as an extremely important sage grouse production and harvest area, where as in 1969, 7,776 hunters spent 17,843 recreational days harvesting 39,876 grouse.

The Flaming Gorge Reservoir and the Green River are the major sport fisheries areas in the oil shale region. Although little data is available on the sport fishery resources in the smaller drainages, some of the more significant trout habitat exists in adjoining headwater streams.

(1) Wyoming Tracts W-a and -b

Adjoining test lease tracts W-a, situated in T14N, R99W, and W-b in T's 13 and 14 N-R99W, lie on Kinney Rim within the Sand Creek-Shell Creek drainage system. This high desert site at a mean elevation of approximately 7,700 feet receives an average 7 inches precipitation annually. Major vegetation on the tracts consists primarily of a sagebrush-grassland association of various indigenous species, interspersed with saltbrush, (Atroplex spp.) and numerous species of forbs.

Despite the rather harsh conditions presented on high, northern desert habitats, a broad variety of wildlife species utilize proposed tracts on Kinney Rim intermittently, seasonally, or on a yearlong basis. Included are mule deer, antelope, wild horse, mountain lion, coyote, bobcat, rabbit, sage grouse, dove, eagle, various raptors, as well as numerous small bird and mammal species. The site is a recognized use area for significant numbers of antelope, wild horses, and sage grouse.

Test-lease tracts W-a and -b are situated in a remote, undeveloped area having semi-primitive characteristics. Although attractive for sport hunting, rock collecting, camping and general sight-seeing, recreational access is limited to dirt roads originating at surfaced highway (Interstate 80) approximately 25-30 miles to the north.

It is estimated that, despite the sparsity of surrounding human populations, and the absence of all-weather access a total of several hundred man-days recreational use are expended annually within test-lease site boundaries.

Currently, much of the land within the Kinney Rim area is covered with active oil and gas leases, giving rise to the potential for some increased future industrial activity related to exploration and extraction. Although this oil and gas interest may result in some limited future impact, it is assumed that without proposed test-lease development, the Kinney Rim site can be expected to retain much of its current recreational values and wildlife productivity over a sustained period of time.

2.f.1 -- Soils and Vegetation (Colorado)

Tract C-a

Topography

Tract C-a has a drainage pattern from southwest to northeast with elevations ranging from approximately 6,600 to 7,400 feet. The lower elevations occur in the drainage bottoms in the northeast portion of the tract. Elevations rise sharply from drainage bottoms to adjacent ridges and increase with the general land slope to the south and west. Precipitation varies from approximately 15 to 18 inches annually.

Soils and Vegetation

The tract contains seven readily identifiable soils units, each having distinctive plant communities.

The following sites occur as indicated as percentages of the total tract area:

Loamy Slopes - 30%
Pinyon Juniper Woodland - 15%
Rolling Loam - 15%
Rough Broken Land - 15%
Deep Loam - 10%
Mountain Swale - 10%
Loamy Breaks - 5%

Each of these sites is described below.

A. Loamy Slopes

1. Vegetative Description - Dominant plants include big sage, serviceberry, dryland sedges, bluebunch wheatgrass, western wheatgrass, Indian ricegrass and balsam root. Total annual yields are 700 to 1500#/acre. Optimum ground cover is about thirty percent.

2. Soils Description - Moderately deep stone-filled dark brown sandy loam to light clay loam soils. The soil surface is also usually stony. Neutral to slightly alkaline reaction. Permeability is moderate; moisture holding capacity is reduced because of stoniness. Fertility level is generally adequate.

3. Present Physical Condition - Located in association with other sites, scattered throughout area. Topography generally steep, erosion is a problem, hazard is high. Present plant cover near potential. Occurs on north and east facing exposures.

B. Pinon-Juniper Woodland

1. Vegetative Description - Indian ricegrass, needle-and-thread grass and bluebunch wheatgrass along with bitterbrush and serviceberry are the important forage plants found on this site in excellent range condition. Often there is an open stand of pinyons and junipers. Production in favorable years can reach as much as 1000 lbs. per acre, air dry. Ground cover is about 25 percent.

2. Soils - These soils are generally very shallow to shallow (0 to 20 inches) over shale and limy fine sandstone parent materials. They are medium to moderately fine textured with a high silt content and varying amounts of rock and stones throughout. There is typically heavy runoff during intense rainstorms. Fertility levels are moderate to low.

3. Present Physical Condition - Range site is frail. Erosion slight to moderate in higher elevation; moderate to severe in lower elevation.

C. Rolling Loam

1. Vegetative Description - An open stand of sagebrush with an abundance of grasses including western wheatgrass, needle-and-thread grass, and native bluegrasses is found when the range is in excellent condition. In favorable years, production is as high as 1000#/acre, air dry weight. Optimum ground cover is about 30 percent.

2. Soil Description - Generally deep, medium to moderately coarse textured soils. Dark grayish brown soils with weak to moderate subsoil development. These soils have a good water holding capacity and take water moderately well making them favorable for good plant growth. Fertility level is generally adequate.

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3. Present Physical Condition - Located in lower elevations, subject to runoff from higher elevations, moderate to severe gully erosion, present plant cover is low compared to potential.

D. Rough Broken Land

1. Vegetative Description - the lands have very sparse vegetation. Wildlife use most important.

2. Soils Description - These soils are very shallow (0 to 10 inches) above parent materials of silty shales or limy fine sandstones. The soils are very erosive and active due largely to very steep slopes and very high runoff. Soil slipping is often common and the steep slopes have a succession of short vertical exposures. Rock outcrops are common. Fertility level is low.

3. Present Physical Condition - Evidenced by geological formations, very steep to vertical outcrops. Lands utilized by wildlife and some livestock.

E. Deep Loam

1. Vegetative Description - The principal plants of this site include big sagebrush, muttongrass, needle-and-thread grass western wheatgrass, bluebunch wheatgrass, and dryland sedges. Forbs commonly associated are hawksbeard, paintbrush, and hairy goldaster. Total annual yield is as much as 1000#/acre in favorable year. Optimum ground cover is about 35 percent.

2. Soils - Moderately deep to deep dark brown sandy loam to light clay loam soils. Soil mixture, subsoil permeability, effective depth, and other soil factors are all favorable for plant growth and help create a productive site. Fertility levels are adequate.

3. Present Physical Condition - Topography is rolling, erosion hazard is severe where vegetative cover is sparse, area subject to intensive summer thundershowers. Topsoil is available.

F. Mountain Swale

1. Vegetative Description - In excellent range condition, the optimum vegetative cover is dominantly grasses such as basin wildrye, wheatgrasses, native bluegrasses and needle grasses. Estimated total annual yield in favorable years is about 3,000#/acre of air dry material. Optimum ground cover is about 50 percent.

2. Soil Description - Weakly developed soils developing in loamy colluvial materials of varied origin. Additional runoff from adjacent uplands causes abundant grass growth which has built up the high organic matter content. Very favorable soil-water-plant relationships. Fertility levels are high.

3. Present Physical Condition - Topography is flat areas in drainage ways. The soils are deep and fertile, adequate for topsoil dressing on other sites for revegetation. Sheet erosion is slight to moderate; gully erosion may be severe in some locations, site receives runoff from adjacent areas, present vegetation is greatly regressed from potential, readily accessible to wildlife and livestock.

G. Loamy Breaks

1. Vegetative Description - Dominant plants include bitterbrush, big sagebrush, serviceberry, Indian ricegrass, and bluebunch wheatgrass. Plant production runs 400 to 800 pounds per acre (per year). Optimum growth cover is about 25 percent.

2. Soils - These soils are shallow, brown to gray brown medium textured loam or stony loam underlain by sandstone or shale. The soils have moderate permeability, but due to the steep slopes, the effective moisture is reduced. This is generally a drouthy and unproductive site.

3. Present Physical Condition - In small scattered locations, mainly associated with pinyon-juniper, slopes are short and steep; vegetation is fairly sparse.

Tract C- b

Topography

Tract C- b has a drainage pattern from south to north with elevations ranging from approximately 6,400 to 7,100 feet. The lower elevations occur in the bottoms of the drainage ways in the north portions of the tract. Elevations rise sharply from the bottoms to the adjacent ridges and increase with the general land slope to the south. Precipitation varies from 15 to 18 inches annually.

Soils and Vegetation

The tract contains eight readily identifiable soil units, each having distinctive plant communities.

The following sites occur as indicated as percentages of the total tract area:

Pinon Juniper Woodland	25%
Loamy Slopes	25%
Rough Broken Land	20%
Rolling Loam	10%
Deep Loam	5%
Mountain Swale	5%
Loamy Breaks	5%
Brushy Loam	5%

Each of these sites are the same as in Tract C-4 except for the one described below:

A. Brushy Loam

1. Vegetative Description - Serviceberry is the dominant appearing plant but a large number of grasses and forbs, together with brushy species, make the site high as a producer. As much as 3000#/acre can be grown in a favorable year. Optimum ground cover is about 60 percent.

2. Soils - Dark brown to very dark brown sandy loam to light clay loam acid topsoil 10 to 20 inches thick. The subsoil is a moderately strongly structured clay loam to light clay, one to four feet thick. It is moderately permeable. The lime zone is deep. There may be a number of stones or cobbles throughout the profile. The soil is very favorable for plant growth. Fertility level is high.

3. Present Physical Condition - Generally located on north slopes. Erosion is slight to moderate. Brush species generally in thick stands. Slopes are generally steep.

Plants Commonly Occurring on Sites in Tracts C-a & C-b

Pinon-Juniper Woodland

Plants

Common	Scientific	Common	Scientific
Indian ricegrass	Oryzopsis hymenoides	Fringed sage	Artemisia frigida
Mutton grass	Poa fendleriana	Rock goldenrod	Solidago petradoria
Needle and thread	Stipa comata	Buckwheat	Eriogonum spp.
June grass	Koeleria cristata	Hairy gold aster	Chrysopsis villosa
Littleseed ricegrass	Oryzopsis micrantha	Globe mallow	Sphaeralcea coccinia
		Loco	Astragalus spp.
Bluebunch Wheatgrass	Agropyron inerme	Phlox	Phlox spp.
		Penstemon	Penstemon spp.
Salina wild-rye	Elymus salinus	Gilia	Gilia aggregata
Western wheatgrass	Agropyron smithii	Bladderpod	Lesquerella spp.
Mountain mahogany	Cercocarpus montanus	Lupine	Lupinus greenei
Bitter brush	Purshia tridentata	Cryptantha	Cryptantha spp.
Mormon tea	Ephedra spp.	Squaw apple	Peraphyllum ramosissimum
Four wing saltbush	Atriplex canescens		
Winterfat	Eurotia lanata	Sage brush	Artemisia tridentata
Indian paintbrush	Castilleja chromosa	Service berry	Amelanchier utahensis
Blue grama	Bouteloua gracilis	Snakeweed	Gutierrezia sarothrae
Galleta	Hilaria jamesii	Skunkbush	Rhus trilobata
Squirrel tail	Sitanion hystrix	Low rabbitbrush	Chrysothamnus viscidiflorus
Sand dropseed	Sporobolus cryptandrus	Snowberry	Symphoricarpos Tetonensis
Sedges	Carex spp.		
Three awn	Aristida spp.	Prickly pear	Opuntia spp.
Sandberg bluegrass	Poa secunda	Stemless goldenweed	Haplopappus acaulis
Yucca	Yucca spp.	Cheatgrass	Bromus tectorum
Russian thistle	Salsola kali	Sleepy grass	Stipa robusta

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Loamy Slopes

Plants

Common	Scientific	Common	Scientific
Bluebunch wheatgrass	Agropyron inerme	Big sagebrush	Artemisia tridentata
Salina wildrye	Elymus salinus	Snowberry	Symphoricarpos tetonensis
Indian ricegrass	Oryzopsis hymenoides		
Muttongrass	Poa fendleriana	Gray horsebrush	Tetradymia canescens
Needle-and-thread grass	Stipa comata	Pinyon pine	Pinus edulis
		Utah juniper	Juniperus osteosperma
Basin wildrye	Elymus cinereus		
Nevada bluegrass	Poa nevadensis	Scarlet globemallow	Sphaeralcea coccinia
Sideoats grama	Bouteloua curtipendula	Indian paintbrush	Castilleja chromosa
		Arrowleaf balsamroot	Balsamorhiza saggitata
Antelope bitterbrush	Purshia tridentata		
		Fremont penstemon	Penstemon fremontii
Mormon tea	Ephedra spp.	Low larkspur	Delphinium nelsoni
Western wheatgrass	Agropyron smithii	Longleaf phlox	Phlox longifolia
Prairie junegrass	Koeleria cristata	Hairy goldaster	Chrysopsis villosa
Sandberg bluegrass	Poa secunda	Stemless goldenweed	Haplopappus acaulis
Bottlebrush squirreltail	Sitanion hystrix	Buckwheat	Eriogonum spp.
		Hoods phlox	Phlox hoodii
Blue grama	Bouteloua gracilis	Mat penstemon	Penstemon caespitosa
Sand dropseed	Sporobolus cryptandrus	Herbaceous sage	Artemisia leudoviciana
Sedges	Carex spp.	Fendler groundsel	Senecio fendleri
Mountain mahogany	Cercocarpus montanus	Pussytoes	Antennaria rosea
Serviceberry	Amelanchier utahensis	Cheatgrass	Bromus tectorum
		Kentucky bluegrass	Poa pratensis
Gambel oak	Quercus gambelii		

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Rolling Loam

Plants

Common	Scientific	Common	Scientific
Bluebunch wheatgrass	Agropyron inerme	Cactus	Opuntia spp.
Nevada bluegrass	Poa nevadensis	Buckwheat	Eriogonum spp.
Indian ricegrass	Oryzopsis hymenoides	Fleabane	Erigeron spp.
Needle and Thread	Stipa comata	Bluebells	Mertensia spp.
Junegrass	Koeleria cristata	Balsamroot	Balsamorhiza saggitata
American vetch	Vicia americana		
Western wheatgrass	Agropyron smithii	Phlox	Phlox spp.
Squirreltail	Sitanion hystrix	Globemallow	Sphaeralcea coccinia
Sandberg bluegrass	Poa secunda	Death camas	Zygadenus gramineous
Big sagebrush	Artemisia tridentata	Lupine	Lupinus greenei
Low rabbitbrush	Chrysothamnus Viscidiflorus	Onion	Allium spp.
		Yarrow	Achillea lanulosa
Tall rabbitbrush	Chrysothamnus Nauseosus	Loco	Astragalus spp.
		Pinyon pine	Pinus edulis
Snakeweed	Gutierrezia sarothrae	Utah juniper	Juniperus osteosperma
Gray horsebrush	Tetradymia canescens		
Serviceberry	Amelanchier utahensis		

2-65

Deep Loam

Plants

Common	Scientific	Common	Scientific
Bluebunch wheatgrass	Agropyron inerme	Indian paintbrush	Castilleja chromosa
Salina wildrye	Elymus salinus	Arrowleaf balsamroot	Balsamorhiza saggitata
Basin wildrye	Elymus cinereus	Fremont penstemon	Penstemon fremontii
Muttongrass	Poa fendleriana	Low larkspur	Delphinium nelsoni
Nevada bluegrass	Poa nevadensis	Longleaf phlox	Phlox longifolia
Needle-and-thread grass	Stipa comata	Hollyleaf clover	Trifolium gymnocarpon
Indian ricegrass	Oryzopsis hymenoides	Bluebells	Mertensia spp.
Tapertip hawksbeard	Crepis acuminata	Gilia	Gilia aggregata
Western wheatgrass	Agropyron smithii	Fleabane	Erigeron spp.
Prairie junegrass	Koeleria cristata	Lupine	Lupinus greenei
Sandberg bluegrass	Poa secunda	Loco	Astragalus spp.
Bottlebrush squirreltail	Sitanion hystrix	Hairy goldaster	Chrysopsis villosa
Letterman needlegrass	Stipa lettermani	Stemless goldenweed	Haplopappus acaulis
Sand dropseed	Sporobolus cryptandrus	Buckwheat	Eriogonum spp.
Big sagebrush	Artemisia tridentata	Hoods phlox	Phlox hoodii
Serviceberry	Amelanchier utahensis	Mat penstemon	Penstemon caespitosa
Snowberry	Symphoricarpos tetonensis	Herbaceous sage	Artemisia leudoviciana
Low rabbitbrush	Chrysothamnus viscidiflorus	Fendler groundsel	Senecio fendleri
Tall rabbitbrush	Chrysothamnus nauseosis	Pusseytoes	Antennaria rosea
Snakeweed	Gutierrezia sarothrae	Cheatgrass	Bromus tectorum
Gambel oak	Quercus gambelii	Kentucky bluegrass	Poa pratensis
Prickly pear cactus	Opuntia spp.	Pinon-pine	Pinus edulis
Scarlet globemallow	Sphaeralcea coccinia	Utah juniper	Juniperus osteosperma

3-66

Mountain Swale

Plants

Common	Scientific
Basin wildrye	Elymus cinereus
Slender wheatgrass	Agropyron trachycaulum
Bearded wheatgrass	Agropyron subsecundum
Nodding brome	Bromus anomalous
Alkali bluegrass	Poa juncifolia
Western wheatgrass	Agropyron smithii
Dryland sedges	Carex spp.
Letterman needlegrass	Stipa lettermani
Columbia needlegrass	Stipa columbiana
Big sagebrush	Artemisia tridentata
Snowberry	Symphoricarpos tetonensis
Chokecherry	Prunus virginiana
Rose	Rosa spp.
Dogwood	Cornus stolonifera
Serviceberry	Amelanchier utahensis
Tall rabbitbrush	Chrysothamnus nauseosus
Low rabbitbrush	Chrysothamnus viscidiflorus
Yarrow	Achillea lanulosa
Geranium	Geranium caespitosum
Herbaceous cinquefoil	Potentilla gracilis
Fleabane	Erigeron spp.
American bistort	Polygonum bistortoides
Stinging nettle	Urtica dioica
Narrow leaf cottonwood	Populus angustifolia
Willow	Salix spp.
Sedges (Aquatic)	Carex spp.
Rushes	Juncus spp.
Kentucky bluegrass	Poa pratensis

2-67

Loamy Breaks

Plants

Common	Scientific	Common	Scientific
Bluebunch wheatgrass	Agropyron inerme	Black sage	Artemisia nova
Needle and thread	Stipa comata	Big sage	Artemisia tridentata
Indian ricegrass	Oryzopsis hymenoides	Low rabbitbrush	Chrysothamnus viscidiflorus
Nevada bluegrass	Poa nevadensis		
Muttongrass	Poa fendleriana	Snakeweed	Gutierrezia sarothrae
Junegrass	Koeleria cristata	Gray horsebrush	Tetradymia canescens
Bitterbrush	Purshia tridentata	Serviceberry	Amelanchier utahensis
Mountain mahogany	Cercocarpus montanus	Buckwheat	Eriogonum spp.
Western wheatgrass	Agropyron smithii	Balsamroot	Balsamorhiza saggitata
Squirreltail	Sitanion hystrix		
Sandberg bluegrass	Poa secunda	Lupine	Lupinus greenei
		Loco	Astragalus spp.
		Stemless goldenweed	Haplopappus acaulis

2-68

Brushy Loam

Plants

Common	Scientific	Common	Scientific
Slender wheat	Agropyron trachycaulum	Big sage	Artemisia tridentata
Mountain brome	Bromus marginatus	Silver sage	Artemisia cana
Nodding brome	Bromus anomalous	Herbaceous sages	Artemisia leudoviciana
Thurber's fescue	Festuca thurberi		
Idaho fescue	Festuca idahoensis	Black sage	Artemisia nova
Mutton grass	Poa fendleriana	Rose	Rosa spp.
Big bluegrass	Poa ampla	Giant hyssop	Agastache urticifolia
Onion grass	Melica bulbosa	Geranium	Geranium caespitosum
Green needlegrass	Stipa viridula	Aster	Aster spp.
American vetch	Vicia americana	Fleabane	Erigeron spp.
Cow parsnip	Heracleum lanatum	Bedstraw	Gallium boreale
Tall bluebells	Mertensia spp.	Lupine	Lupinus greenei
Mountain muhly	Muhlenbergia montana	Yarrow	Achillea lanulosa
Bitterbrush	Purshia tridentata	Balsamroot	Balsamorhiza saggitata
Western wheat	Agropyron smithii		
Letterman's needlegrass	Stipa lettermani	Meadow rue	Thalictrum fendleri
		Penstemon	Penstemon spp.
Columbia needlegrass	Stipa columbiana	Rocky Mountain golden pea	Thermopsis montana
June grass	Koeleria cristata	Leafy polemonium	Polemonium foliosissimum
Squirreltail	Sitanion hystrix		
Basin wildrye	Elymus cinereus	Yampa	Perideridia gairdneri
Indian ricegrass	Oryzopsis hymenoides	Starwort	Stellaria jamesiana
Elk sedge	Carex geyeri	Herbaceous cinquefoil	Potentilla gracilis
Oak	Quercus gambelii		
Serviceberry	Amelanchier utahensis	Wyethia	Wyethia amplexicaulis
Snowberry	Symphoricarpos tetonensis	Buckwheat	Eriogonum spp.
		Rockcress	Arabis spp.
Mountain mahogany	Cercocarpus montanus	Oregon grape	Berberis repens
Fendler bush	Ceanothus fendleri	Aspen peavine	Lathyrus leucanthus
		Timber poisonvetch	Astragalus diversifolius
		Low larkspur	Delphinium nelsoni
		Loco	Astragalus spp.
		Tall rabbitbrush	Chrysothamnus nauseosus
		Knotweed	Polygonum aviculare
		Sleepy grass	Stipa robusta
		Kentucky bluegrass	Poa pratensis

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Rough Broken Land

This site commonly supports no vegetation because of the steepness of the slopes, lack of topsoil, and high degree of erosion. The following plants occur sparsely on the site:

On north-facing slopes -

Serviceberry	Amelanchier utahensis
Antelope bitterbrush	Purshia tridentata
Currant	Ribes spp.
Skunkbush	Rhus trilobeta
Juniper	Juniperus osteosperma
Pinyon pine	Pinus Edulis
Western wallflower	Erysimum aspermum
Loco	Astragalus spp.
Primrose	Oenothera spp.
Penstemon	Penstemon spp.
Bluebunch wheatgrass	Agropyron inerme
Indian ricegrass	Oryzopsis hymenoides
Squirreltail	Sitanion hystrix
Needle and thread	Stipa comata
Mutton grass	Poa fendleriana

on south facing slopes -

Saltbush	Atroplex spp.
Horsebrush	Tetradymia canescens
Rabbitbrush	Chrysothamnus spp.
Winterfat	Eurotia lanata
Phlox	Phlox spp.
Goldenweed	Haplopappus spp.
Daisy	Erigeron spp.

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2.f.2 -- Soils and Vegetation (Utah)

Tract U-a and -b

Topography

Tracts U-a & b have a drainage pattern from south to north with elevations ranging from approximately 4,900 to 5,900 feet. The lowest elevation occurs on the White River at the north edge of the tracts. Elevations rise sharply from the drainage ways to ridge tops and mesas. Precipitation varies from approximately 8 to 10 inches annually.

Soils and Vegetation

These tracts contain four identifiable soil units, each having distinctive plant communities.

The following sites occur as approximate percentages of the total tract area.

Pinyon Juniper Woodland	55%
Salt Desert Breaks	25%
Loamy Saltdesert	5%
Rough Broken Land	15%

Each of these sites are described below.

A. Pinyon-Juniper Woodland

1. Vegetative Description - Needle-and-thread grass, Indian ricegrass and mutton grass along with bitterbrush and serviceberry are the important plants found on this site in good to excellent range condition. Often the stand of pinyon and junipers is scattered. Production in favorable years can reach as much as 800 lbs. per acre of air dry forage. Ground cover is about 20 percent.

2. Soils - Soils are generally shallow (10-20 inches deep) over a calcareous sandstone and siltstone type bedrock. They are moderately fine to moderately coarse textured and have a moderate moisture intake rate. Available moisture holding capacity is moderate to low. Fertility level is moderate to low.

3. Present Physical Condition - Range site is fragile. Erosion moderate to severe. There is typically heavy runoff during intense rainstorms.

B. Salt Desert Breaks

1. Vegetative Description - Galleta junegrass, Indian ricegrass and needle-and-thread grass along with winterfat, four-wing saltbush, and greasebush are the important forage

plants found on this site in good to excellent range condition. There may be a few scattered pinyon and juniper trees on this site. Production in favorable years is approximately 300 to 600 pounds per acre of air dry forage. Ground cover is about 15 to 20 percent.

2. Soils - Soils are quite variable ranging from light textured loams to clay loams and in many places, there are many stones on the surface and in the profile. Soil depth varies from exposed bedrock in many places to deep soils.

3. Present Physical Condition - Range site is fragile. Runoff during heavy rainstorms will be high and erosion hazard is moderate to severe, depending on site condition.

C. Loamy Saltdesert

1. Vegetative Description - Galleta, salina wildrye, Indian ricegrass, and needle-and-thread grass along with bud sage, winterfat, shadscale and fourwing saltbush are the important forage plants found on this site in good to excellent range condition. Production in favorable years can reach 300 to 500 pounds of air dry forage per acre. Optimum ground civer is about 25 percent.

2. Soils - These soils are generally moderately deep to deep with a loam to clay loam texture. They have a moderate to good water holding capacity and a moderate to slow water intake rate. These soils generally occur on gently sloping to moderate slopes. Fertility levels are adequate.

3. Present Physical Condition - This is a fragile site. Erosion hazard is high if vegetative cover is destroyed. This site occurs on gentle to moderately sloping areas.

D. Rough Broken Land

This land type consists mainly of the steep walls of canyons. The sides of the canyons are a series of narrow terraces that have nearly vertical walls of sandstone and siltstone. On these narrow terraces, a thin mantle of stony soil supports a sparse growth of juniper, pinyon, big sagebrush, black sagebrush, bullgrass, Indian ricegrass, and native bluegrass.

Runoff and erosion can be quite high on this site during intense summer rainstorms.

Plants Commonly Occurring on Sites in Tracts U-a & U-b

Pinyon-Juniper Woodland

Plants

Common	Scientific	Common	Scientific
Indian ricegrass	Oryzopsis hymenoides	Buckwheat	Eriogonum spp.
Mutton grass	Poa fendleriana	Hairy goldaster	Chrysopsis villosa
Needle and thread	Stipa comata	Globe mallow	Sphaeralcea coccinia
Littleseed ricegrass	Oryzopsis micrantha	Loco	Astragalus spp.
		Phlox	Phlox spp
Bluebunch wheatgrass	Agropyron inerme	Penstemon	Penstemon spp.
		Gilia	Gilia aggregata
Salina wild-rye	Elymus salinus	Bladderpod	Lesquerella spp.
Western wheatgrass	Agropyron smithii	Lupine	Lupinus greenei
Mountain mahogany	Cercocarpus montanus	Cryptantha	Cryptantha spp.
Bitter brush	Purshia tridentata	Sage brush	Artemisia tridentata
Mormon tea	Ephedra spp.	Serviceberry	Amelanchier utahensis
Fourwing saltbush	Atriplex canescens	Snakeweed	Gutierrezia sarothrae
Winterfat	Erotia lanata	Skunkbush	Rhus trilobata
Cliffrose	Cowania mexicana	Low rabbitbrush	Chrysothamnus viscidiflorus
Indian paintbrush	Castilleja chromosa		
Galleta	Hilaria jamesii	Snowberry	Symphoricarpos Tetonensis
Squirrel tail	Sitanion hystrix		
Sand dropseed	Sporobolus cryptandrus	Prickly pear	Opuntia spp.
		Stemless goldenweed	Haplopappus acaulis
Sedges	Carex spp.	Cheatgrass	Bromus tectorum
Three awn	Aristida spp.	Sleepy grass	Stipa robusta
Sandberg bluegrass	Poa secunda	Russian thistle	Salsola kali
Yucca	Yucca spp.		
Rock goldenrod	Solidago petradoria		

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Salt Desert Breaks

Plants

Common	Scientific	Common	Scientific
Galleta	Hilaria jamesii	Blue grama	Bouteloua gracilis
Indian ricegrass	Oryzopsis hymenoides	Western wheatgrass	Agropyron smithii
Needle and thread	Stipa comata	Three awn	Aristida spp.
Salina wildrye	Elymus salinus	Gilia	Gilia aggregata
Junegrass	Koeleria cristata	Death camas	Zygadenus elegans
Bluebunch wheatgrass	Agropyron inerme	Larkspur	Delphinium nelsoni
Alkali sacaton	Sporobolus airoides	Loco	Astragalus spp.
Globe mallow	Sphaeralcea coccinia	Aster	Aster spp.
Sego lily	Calochortus spp.	Daisy	Erigeron spp.
Indian paintbrush	Castilleja chromosa	Wild buckwheat	Eriogonum spp.
Winterfat	Eurotia lanata	Mat saltbush	Atriplex currugata
Bud sage	Artemisia spinescens	Snakeweed	Gutierrezia sarothrae
Four wing saltbush	Atriplex canescens	Rabbitbrush	Chrysothamnus spp.
Greasebush	Forsellesia spinescens	Cactus	Opuntia spp.
Mormon tea	Ephedra spp.	Yucca	Yucca spp.
Squirrel tail	Sitanion hystrix	Shadscale	Atriplex confertifolia
Sand dropseed	Sporobolus cryptandrus	Spiny horsebrush	Tetradymia spinosa
		Juniper	Juniperus utahensis
		Greasewood	Sarcobatus vermiculatus

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Loamy Saltdesert

Plants

Common	Scientific	Common	Scientific
Galleta	Hilaria jamesii	Three awn	Aristida longiseta
Indian ricegrass	Oryzopsis hymenoides	Shadscale	Atriplex confertifolia
Needle and thread	Stipa comata		
Thickspike wheatgrass	Agropyron dasystachyum	Big rabbitbrush	Chrysothamnus Nauseosus
Globemallow	Sphaeralcea coccinia	Spiny horsebrush	Tetradymia spinescens
Mutton grass	Poa fendleriana	Prickly pear cactus	Opuntia spp.
Squirrel tail	Sitanion hystrix	Snakeweed	Gutierrezia sarothrae
Spiny hopsage	Grayia spinosa	Phlox	Phlox spp.
Salina wildrye	Elymus salinus	Buckwheat	Eriogonum spp.
Bud sagebrush	Artemisia spinescens	Loco	Astragalus spp.
Black sagebrush	Artemisia nova	Aster	Aster spp.
Winterfat	Eurotia lanata	Paintbrush	Castilleja chromosa
Big sagebrush	Artemisia tridentata	Russian thistle	Salsola kali
Sandberg bluegrass	Poa secunda	Cheatgrass	Bromus tectorum
Sand dropseed	Sporobolus cryptandrus	Halogeton	Halogeton glomeratus

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2.f.3 -- Soils and Vegetation (Wyoming)

Tract W-a and -b

Topography

Tract W-a has a drainage pattern which drains two directions, from a high ridge which traverses the tract from the southeast to the northwest. Eighty percent of the area drains to the northeast and about twenty percent to the southwest. The terrain drops almost vertically to the southwest and very sharply to the northeast. Elevation ranges from 7,200 feet to 8,200 feet. Average annual precipitation is about 10 inches, fairly evenly distributed throughout the year.

Soils and Vegetation

The tract contains four identifiable sites, each having distinctive kinds of soils and plant communities.

The following sites occur as indicated as percentages of the total tract area:

Very Shallow	64%
Saline Upland	21%
Shallow Sandy	14%
Saline Lowland	1%

Each of the sites is described below:

A. Very Shallow

1. Vegetative Description - Dominant plants include bluebunch wheatgrass, thickspike wheatgrass, black sagebrush, and mountain mahogany. Total annual yields are about 500 to 800 lbs. air dry forage per acre. Optimum ground cover is about 25 percent.

2. Soils Description - This site has very shallow soils 10 to 20 inches over sandstone and shale. In places, bedrock is exposed. Texture varies from loam to clay loam and they have an alkaline to strongly alkaline reaction.

3. Present Physical Condition - Topography is generally steep with slopes mostly in the 10 to 20 percent range. Erosion is moderate.

B. Saline Upland

1. Vegetative Description - The most important species on this site are western wheatgrass, Indian ricegrass, gardener's saltbush, big sagebrush, and shadscale. Production in favorable years varies from 200 to 500 lbs. of air dry forage. Optimum ground cover is about 15 percent.

2. Soils Description - Soils in this site are shallow to moderately deep, 20 to 40 inches over shale and sandstone. Texture varies from sandy loam to light clay loam and reaction from alkaline to strongly alkaline. Permeability is moderate; moisture holding capacity is moderate. Fertility level is low to moderate.

3. Present Physical Condition - Topography is generally quite steep with slopes of 20 to 30 percent. Runoff is rapid, erosion hazard is high. Present plant cover is about 40 percent of potential.

C. Shallow Sandy

1. Vegetative Description - The most important plants are sandberg bluegrass, indian ricegrass, bluebunch wheatgrass, shadscale, and sagebrush occurring on the site in good to excellent range condition. Production in favorable years is about 400 to 600 lbs. of air dry forage. Optimum ground cover is about 20 percent.

2. Soils Description - These soils are moderately sandy to sandy over sandstone, with many stones on the surface and in the profile. Water holding capacity is low. Fertility level is low.

3. Present Physical Condition - Range site is fragile. Topography moderately sloping with 5 to 10 percent slopes. At present, the site is producing about 40 percent of the potential plant community. Erosion is moderate.

D. Saline Lowland

1. Vegetative Description - Inland saltgrass, basin wildrye, alkali sacaton, sedges and greasewood are the most important forage plants occurring on this site in good to excellent range condition. Production in favorable years will be about 500 to 700 lbs. of air dry forage per acre. Optimum ground cover is about 25 percent.

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2. Soils Description - These soils are generally deep and are loam to clay loam in texture. They are moderate to strongly alkaline in reaction. Water intake rate is moderate to slow and water holding capacity is high. Fertility level is moderate to high.

3. Present Physical Condition - Topography is gently sloping. Erosion is moderate -- may be severe if gullies are started. At present, the site is producing about 50 percent of the potential plant community.

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Plants Commonly Occurring on Sites in Tract W-a

Very Shallow

Plants

Common	Scientific	Common	Scientific
Dryland sedge	Carex spp.	Violet	Viola spp.
Prairie junegrass	Koeleria cristata	Bitterbrush	Purshia tridentata
Western wheatgrass	Agropyron smithii	Mountain mahogany	Cercocarpus montanus
Sandberg bluegrass	Poa secunda	Needleleaf sedge	Carex eleocharis
Big sagebrush	Artemisia tridentata	Three awn	Aristida spp.
Black sagebrush	Artemisia nova	Aster	Aster spp.
Juniper	Juniperus osteosperma	Buscuit root	Lomatuim spp.
Rabbitbrush	Chrysothamnus spp.	Eriogonum	Eriogonum spp.
Skunkbush	Rhus trilobeta	Fleabane	Erigeron spp.
Winterfat	Eurotia lanata	Indian Paintbrush	Castilleja chromosa
Bluebunch wheatgrass	Agropyron spicatum	Phlox	Phlox spp.
Bottlebrush squirreltail	Sitanion hystrix	Pointvetch	Oxytropis lambertii
Canby bluegrass	Poa canbyi	Milkvetch	Astragalus bisulcatus
Indian ricegrass	Oryzopsis hymenoides	Pusseytoes	Antennaria rosea
Letterman's needlegrass	Stipa lettermani	Scarlet globemallow	Sphaeralcea coccinia
Mutton bluegrass	Poa fendleriana	Stone crop	Sedum spp.
Needle and thread grass	Stipa comata	Western yarrow	Achillea lanulosa
Thickspike wheatgrass	Agropyron dasytachyum		
Penstemon	Penstemon spp.		

2-79

Saline Upland

Plants

Common	Scientific	Common	Scientific
Western wheatgrass	Agropyron smithii	Death camas	Zygadenus elegans
Greasewood	Sarcobatus vermiculatus	Eriogonum	Eriogonum spp.
Winterfat	Eurotia lanata	Fleabane	Erigeron spp.
Alkali sacaton	Sporobolus airoides	Milkvetch	Astragalus bisulcatus
Bottlebrush squirreltail	Sitanion hystrix	Prince's plume	Stanleya pinnata
Indian ricegrass	Oryzopsis hymenoides	Phlox	Phlox spp.
Needle and thread grass	Stipa comata	Pointvetch	Oxytropis lambertii
Gardner's saltbush	Atriplex nuttalli	Primrose	Oenothera spp.
Sandberg bluegrass	Poa secunda	Pusseytoes	Antennaria rosea
Aster	Aster spp.		

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Shallow Sandy

Plants

Common	Scientific	Common	Scientific
Dryland sedge	Carex spp.	Mutton bluegrass	Poa fendleriana
Plains reedgrass	Calamovilfa longifolia	Needle and thread grass	Stipa comata
Prairie junegrass	Koeleria cristata	Thickspike wheatgrass	Agropyron dasytachyum
Western wheatgrass	Agropyron smithii		
Sandberg bluegrass	Poa secunda	Penstemons	Penstemon spp.
Big sagebrush	Artemisia tridentata	Bitterbrush	Purshia tridentata
Juniper	Juniperus osteosperma	Needle leaf sedge	Carex eleocharis
		Asters	Aster spp.
Rabbitbrush	Chrysothamnus spp.	Eriogonum	Eriogonum spp.
Skunkbush	Rhus trilobeta	Fleabane	Erigeron spp.
Winterfat	Eurotia lanata	Hawksbeard	Crepis acuminata
Bluebunch wheatgrass	Agropyron spicatum	Milkvetch	Astragalus bisulcatus
Bottlebrush squirreltail	Sitanion hystrix	Indian Paintbrush	Castilleja chromosa
		Phlox	Phlox spp.
Canby bluegrass	Poa canbyi	Western Yarrow	Achillea lanulosa
Indian ricegrass	Oryzopsis hymenoides		
Letterman's needlegrass	Stipa lettermani		

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Saline Lowland

Plants

Common	Scientific	Common	Scientific
Inland saltgrass	Distichlis stricta	Pointvetch	Oxytropis lambertii
Dryland sedge	Carex spp.	Alkali sacaton	Sporobolus airoides
Mat Muhly	Muhlenbergia Richardsonis	Basin wildrye	Elymus cinereus
Western wheatgrass	Agropyron smithii	Bluebunch wheatgrass	Agropyron spicatum
Sandberg bluegrass	Poa secunda	Squirrel tail	Sitanion hystrix
Greasewood	Sarcobatus vermiculatus	Indian ricegrass	Oryzopsis hymenoides
Rabbitbrush	Chrysothamnus spp.	Nuttall's alkaligrass	Puccinellia nuttallii
Skunkbush	Rhus trilobeta	Four wing saltbush	Atriplex canescens
Milkvetch	Astragalus bisulcatus	Gardner's salt	Atriplex nuttallii
Poverty weed	Iva axillaris	Alkali muhly	Muhlenbergia asperifolia

2.g.1 -- Socio- Economic Setting (Colorado)

Tracts C-a and -b The northern boundary of the shale area is approximately marked by the White River Valley, a remote and isolated valley in a thinly settled area with two communities, Meeker and Rangely, each having a population of about 1,500.

The principal industries in the region are grazing of livestock and the extraction of minerals. Rangely, in Rio Blanco County, is the site of Colorado's largest oil field, and exists principally as an oil and gas center. Grand Junction, the principal community of Western Colorado, is a transportation hub with rail, truck and highway communication with Western Colorado and more distant points, and with frequent jet air service principally to Denver and Salt Lake City. Grand Junction is also a commercial and medical center for the region with a number of wholesale supply firms and services, as well as medical, educational, and other professional services.

Rifle, situated in Garfield County on the Colorado River at the Southwestern corner of the Piceance Creek Basin, has historically been oriented more towards industrial activity. It is the site of the Union Carbide vanadium-uranium mill and is the nearest community to the Bureau of Mines' plant at Anvil Points. The Denver and Rio Grande Railroad has made it a shipping point for livestock from the Piceance Creek Basin.

To the east is the county seat of Garfield County, Glenwood Springs, situated at the junction of the Roaring Fork and Colorado Rivers. This community has become the focal point of distribution of goods and services to the very large areas drained by the Colorado, Eagle, Roaring Fork, Frying Pan and Crystal Rivers. In addition, it has been a center for

local State and Federal offices. It has a population of about 4,000 and is well served by medical and educational facilities.

In 1964 Rio Blanco County, which now has a population of about 4,800, became concerned generally with the increasing pace of recreational land sales and with the possibility of the rapid development of an oil shale industry. The Board of County Commissioners appointed a planning commission which, in turn, engaged Small, Cooley and Associates of Denver as planning consultants.

In the Subdivision Regulations of Rio Blanco County, covering by far the greater portion of the Piceance Creek Basin, are protections against the speculative development of unimproved land, and sales of land by mail, as well as protection against strip development of land along, for example, Piceance Creek or one of its tributaries.

In addition to the Subdivision Regulations, the mobile home regulations of Rio Blanco County, which, again, cover substantially all of the Piceance Creek Basin, are anticipated to be a major safeguard against strip development, shanty-town development in or near an area of oil shale activity, speculative land uses not having proper safeguards towards air and water pollution, and blights on the landscape.

At the time the subdivision regulations and mobile home regulations were being considered, the road and highway network of Rio Blanco County was being studied by the Planning Commission. Access from Meeker, the county seat, into the Piceance Creek Basin and access to the oil shale in the basin were thoroughly considered. As a result of these studies, it was recommended to the Board of County Commissioners of Rio Blanco County that the county road along Piceance Creek, an improved gravel road, be brought to state

highway standards and paved. The County Commissioners followed this recommendation and more than one million dollars was spent by the county on the acquisition of rights-of-way, engineering, construction and paving of this highway which is now paved from its terminus at Rio Blanco on State Highway 13 to the other terminus at the White River at the mouth of Piceance Creek on State Highway 64.

Pursuant to a county zoning plan developed by the Planning Commission, the entire Piceance Creek Basin, as well as nearly all the rest of the county, was zoned A-Agricultural. This zoning classification permits, generally, farm buildings, dwellings, churches, guest ranches, public recreation areas, public utilities, schools, vacation homes and cabins, and certain specified temporary uses. The uses allowed with planning commission approval include cemeteries, commercial feed yards, slaughterhouses, mines, quarries, sand and tank batteries. Any use is subject, of course, to prohibitions on air or water pollution, compatibility with existing uses, scarring of land, and restrictions on unsightly aspects, odors, and noise. It should be emphasized that mineral research sites are allowed as temporary uses in the Piceance Creek Basin without a change in the zoning plan if they do not create air or water pollution, and if they satisfy the requirements of the zoning resolution.

The present public facilities in Western Colorado, generally, can support a population well in excess of the present population.

Rio Blanco County, with its tax base primarily supported from the two largest oil fields in Colorado, operates with a relatively secure public revenue source. Because of this secure public fund situation, and aided by

past programs of the Colorado Department of Highways and the Colorado General Assembly, and because of the public interest of its citizens, the community is well provided with public facilities.

The school system for Rangely and Meeker are outstanding, and their physical plants can accommodate an influx of students without strain. Rangely supports a junior college with two year courses.

Each community has a hospital of more than 20 beds. Each hospital is well supported and adequately staffed and equipped. The county roads are paved and the communities each have adequate water systems and sewage disposal systems.

Among Meeker's charitable endowments is the Freeman E. Fairfield Meeker Charitable Trust, a fund of two million dollars, the income of which is devoted annually to charitable, educational, scientific, literary, and religious purposes in the Meeker community. A library adequate for the needs of the community is now being planned. The parks, churches, community and health facilities all combine to make Meeker a town in which there is increasing development of homes by retired persons and professionals anxious to leave the cities. Rangely supports a junior college through the oil tax revenues and is a center for mineral development in the region. Rangely, Rifle and Meeker each have paved, lighted airports, and the highway communication in the region is satisfactory. The nearest airports of jet capability are at Grand Junction and Hayden, but the F.A.A has current surveys underway for construction of an airport of jet capability at Meeker.

2.g.2 -- Socio-Economic Setting (Utah)

Tracts U-a and -b

These tracts are located approximately 20 miles southwest of Rangely, Colorado and approximately 40 miles southeast of Vernal, Utah. It is anticipated that these two towns would provide the community services for oil shale development on the Utah tracts. The socio-economic conditions at Rangely have been discussed above.

Vernal, Utah is a town of approximately 4,000 population in the center of the Ashley Valley. The Valley is 48 square miles in area and supports a population of nine to ten thousand. The primary industries in the Vernal area are oil and mining, agriculture and tourism. The community has a dependable water supply from Ashley Creek and Ashley Springs. The town of Vernal supplies water to the entire Valley through a pipeline system. Vernal is the service center for the Rangely oil field, Ashley oil field and newly developing oil fields in adjacent Duchesne County. It is also the center for a phosphate mining enterprise 12 miles from the town and the Gilsonite Mines at Bonanza, Utah.

The city of Vernal and Uintah County maintain a planning commission, which has developed a planning and zoning program for the entire County. The community is progressive, has continually expanded its school system to meet demands. The city maintains a 30-bed hospital, which is being enlarged to 50 beds. There is presently an acute shortage of physicians in the town.

The town is located on U. S. Highway 40, a major east-west artery. It has no railroad. The town maintains an airport facility with a 6,000 foot runway. It has Frontier air service principally to Denver, Salt Lake City, and Grand Junction.

Agricultural enterprises are primarily large livestock ranches with small acreages of irrigated hay and pasture lands in the drainage bottoms. The town has many tourist attractions, including the nearby Dinosaur National Monument, an outstanding geological museum, and excellent fishing, hunting and camping facilities in nearby national forests and the Flaming Gorge Reservoir Recreation Area.

2.g.3 -- Socio-Economic Setting (Wyoming)

Tracts W-a and -b

These tracts are located approximately 40 miles southeast of Rock Springs, Wyoming. It is anticipated that Rock Springs would provide the community services for oil shale development on the Wyoming tracts.

Rock Springs, Wyoming is a city of approximately 15,000 population. It is located on Interstate 80 and is served by the Union Pacific Railroad .

Economic base for the community is primarily oil and minerals and related service enterprises. Natural resources of the area include coal, oil, and trona. The community is presently experiencing a period of high growth and development. A 300,000 steam plant is under construction by the Pacific Power and Light Company, which will add an anticipated 1,200 people to the community's population.

The community is served by Frontier Airlines, which provides air service to Denver and Salt Lake City on a daily basis. The town has an adequate school system, including a two-year community college. Water is supplied from the Green River and is adequate to meet present and future anticipated needs. The city also has a 101-bed hospital. The city has an active planning commission and has developed a city plan and zoning regulation with 701 HUD funds.

City plans include expansion of water and sewer facilities to accommodate an additional 10,000 people. Recreation facilities are limited in the community, but the national recreation area at Flaming Gorge Reservoir is within 30 miles of the community.

2.h.1 -- Land Status (Colorado)

Tract C-a Surface and mineral rights on this tract are owned by the United States except for provisions listed below.

T. 1 S., R. 99 W.

A. Section 33

1. NE¼SE¼, S½SE¼, SE¼SW¼

The surface and the unreserved minerals are owned by the "Shields and Caldwell Hunting Camp," c/o Charles F. Shields, Box 188, Murrieta, CA 92362. "Oil and gas and all shale or other rock valuable as a source of petroleum and nitrogen in the lands so patented" are reserved to the United States; Patent 871543. Act of July 17, 1914.

Section 33

2. NE¼, SE¼NW¼, NW¼SE¼, NE¼SW¼

The surface is owned by the Colorado Game, Fish and Parks Department. All minerals are reserved to the United States; Patent 1031800; Act of Dec. 29, 1916.

B. Section 34

1. NW¼NW¼, S½N½, NW¼SW¼

The surface is owned by the Colorado Game, Fish and Parks Department. Fifty percent of the unreserved minerals are owned by the Colorado Game, Fish and Parks Department, and 50% are owned by Bell Petroleum Co. The minerals reserved to the United States are "oil and gas and all shale or other rock valuable as a source of petroleum and nitrogen in the lands so patented"; Patent 990142; Act of July 17, 1914.

Tract C-b

There is no patented land in this site, but public access may be blocked by private lands along Piceance Creek.

2.h.2 -- Land Status (Utah)

Tracts U-a and -b   Surface and mineral rights on these tracts are owned by the United States except for provisions listed below.

T. 10 S., R. 24 E.

A. Section 14

1. NW¼NW¼

Surfaced owned by LaRue Pickup and others; oil and gas and oil shale are reserved to the United States.

2.h.3 -- Land Status (Wyoming)

Tracts W-a and -b   All surface and mineral rights on these tracts are owned by the United States, with the exception of 40 acres of patented land, with no minerals reserved to the U.S., in NW¼NE¼, Sec. 1, T. 13 N., R. 99W.

2.i.1 -- Grazing (Colorado)

Tract C-a The vegetative types existing on this site offer forage and protective cover to wildlife and cattle.

The cattle utilize the area generally during the Spring and Fall averaging about five months. The site and waste area lays across normal routes of travel from lower ranges to the higher elevations.

Six hundred animal unit months of feed are produced on the site for cattle. There are two separate ranch operations with 1200 head of cattle grazing allotments that cover an area around the site.

Fences and water facilities are located on and adjacent to the site to control the livestock and service the area.

Tract C-b The vegetative types existing on this site offer forage and protective cover to wildlife and cattle.

The cattle utilize the area generally during the Spring and Fall averaging about five months. The selected site and waste area lays across normal routes of travel from lower ranges to the higher elevations.

Six hundred fifty animal unit months of feed are produced on the site for cattle. There are five separate ranch operations with 7,781 head of cattle grazing a common allotment that covers an area around the site.

Fences and water facilities are located on and adjacent to the site to control the livestock and service the area.

2.i.2 -- Grazing (Utah)

Tract U-a Average forage density by ocular estimate varies from 3% to 15% and average vegetative yield approximates 350#/acre on fair range sites.

The growing season for the various plants within the lease area generally begins around late March (3/25). Seed dissemination for the grass species is July - August, October - November for shrub species.

The lands are used by two bands of sheep for winter grazing. A total of 730 AUM's are utilized by 1400 sheep during the winter grazing season. There is negligible use of the proposed tract by wild horses. Deer inhabit the breaks along the White River and consume about 110 AUM's of forage.

Tract U-b Average forage density by ocular estimate varies from 3% to 15% and average vegetative yield approximates 350#/acre on fair range sites.

The growing season for the various plants within the lease area generally begins around late March (3/25). Seed dissemination for the grass species is July - August, October - November for shrub species.

The area is used for winter sheep grazing by three livestock operators - Daniel and Jerry B. Seely, Tom Theos, and Nick Theos. Together these operators graze about 1400 sheep on the area which consume about 730 Aum's of forage each year. Also, deer inhabit the breaks along the White River and consume about 110 Aum's of forage.

Stocking has been adjusted to the carrying capacity of the range. About 11,000 sheep trail through the tract twice each year. This livestock trail is located along the main county road and Southam Canyon Road (see map).

The area has periodic infestations of poison weeds including loco weed (Astragalus spp.) and halogeton (Halogeton Glomeratus). Loco weed thrives after a favorably wet summer and is grazed in its green stage in the winter. Halogeton has a tendency to rapidly invade all disturbed soils.

2.i.3 -- Grazing (Wyoming)

Tracts W-a and -b Sheep belonging to two operators use the nominated areas during the late fall, winter and spring period. Cattle belonging to one operator use the nominated site area during the summer and fall.

There is very little potential for additional livestock forage production except through (1) water development to improve distribution and (2) limited vegetative manipulation by seeding or sagebrush spraying.

The major livestock oriented problem is lack of water for proper distribution. There are several springs in the immediate area, primarily along the east slope of Kinney Rim. Stockwater reservoirs are widely scattered throughout the surrounding area, therefore existing watering areas are very important.

Any damage to this water source as a result of oil shale development, either to the ground water supply or contamination of the surface water, would result in serious effects on livestock and wildlife use.

2.j.1 -- Aesthetics (Colorado)

Tract C-a The primary aesthetic value of this site is the quiet and the unobstructed scenery. The air is clean and visibility is limited only by natural land forms and the horizon. Visibility ranges of 100 miles or more are common.

The main roads are in drainage bottoms and are not visible in general views of the area. Other works of man are limited and obstruct the view only in limited areas.

Noise associated with man's activities, that can be heard at any distance from the point of origin, is limited to scattered drilling rigs exploring for oil or gas or coring the oil shale.

The Cathedral Bluffs, west of the mine site, are an unusual land form. They are nearly vertical rock cliffs several hundred feet in height. They are visible for several miles from the north and west as well as from the highway from Rangely to Grand Junction. The Bluffs are considered a scenic area because of their gray color and unique form.

Tract C-b

The primary aesthetic value of this site is the quiet and the unobstructed scenery. The air is clean and visibility is limited only by natural land forms and the horizon. Visibility ranges of 100 miles or more are common.

The main roads are in drainage bottoms and are not visible in general views of the area. Other works of man are limited and obstruct the view only in limited areas.

Noise associated with man's activities, that can be heard at any distance from the point of origin, is limited to scattered drilling rigs exploring for oil or gas or coring the oil shale.

2.j.2 -- Aesthetics (Utah)

Tracts U-a and -b The landscape along the south side of the White River is characterized generally by desert shrub and pinyon-juniper vegetative communities. The terrain is sharply cut by deep canyons with numerous buttes and spires. The red and white rock formations contrast with the dark green juniper trees to form a highly aesthetic semi-desert landscape. Wildlife and domestic animals utilize the area for winter grazing. They are often visible from travel routes.

There is only one known significant geological feature in the area. This is an eroded ledge that forms the figure of a duck.

The only body of water suitable for recreation use is the White River, which flows for approximately one mile through the north edge of the tracts. Although present recreation use on the White River is very light (consisting of floating, fishing, and picnicking), the river does provide some scenic breaks along the banks.

2.j.3 -- Aesthetics (Wyoming)

Tracts W-a and -b The aesthetics attraction of the basin is the land form; notable the Kinney Rim escarpment, which extends for about twenty miles, uncluttered and semi-remote in character. The area is sparsely inhabited and only few primitive roads exist.

2.k.1 -- Recreation (Colorado)

Tracts C-a and -b

The 639,000 acres of the Piceance Creek Basin provides a significant portion of the habitat for the largest migratory herd of mule deer in the U. S. Tracts C-a and C-b include approximately 10,240 acres within the Basin. The hunting of mule deer during the last two weeks of October is the major recreation use of the Basin annually. Game, Fish and Parks Division records show that over 5,000 hunters visit the area each year during the hunting season and harvest an average of 5,500 deer. A few elk and black bears are also taken each year in the Basin but these animals do not normally inhabit tracts C-a or C-b.

Non-residents constitute a large proportion of the Piceance Creek hunters. Many utilize trailers or campers brought from their home states. Local ranchers commonly guide out of state hunters from their ranch headquarters for a fee.

The area supports several small game species including cottontail rabbits, mourning doves, and sage grouse. Cottontail rabbits are hunted during big game season and to a lesser degree at other times of the year. They are found on both tracts C-a and C-b.

The Piceance Creek Basin is semi wilderness in nature and is generally accessible to motor vehicles. While the area has notable scenic values it is visited sparingly by tourists at times other than during the big game hunting season. This is probably because of the proximity of the area to more desirable country with high recreation values.

Fishing in the Basin is limited to several man made ponds in the major drainage bottoms and in the headwaters of several small live streams. There is no fishing potential on tracts C-a or C-b.

There are no commercial recreation facilities within the Basin other

than ranch headquarters. Recreational access by 4-wheel drive vehicles is impaired as a result of private ownership on adjacent lands. On Tract C-a, a local hunting club having surface patent rights utilizes four small buildings as a hunting camp during the big game hunting season.

Service centers utilized by hunters and local recreationists are the towns of Rifle, Meeker, and Rangely; each about 20 miles from the Basin perimeter. These communities also serve fishermen, hunters, winter sports participants and campers utilizing the high quality recreation facilities of the White River National Forest and surrounding area.

2.k.2 -- Recreation (Utah)

Tracts U-a and -b There are no developed recreation facilities in the area. Recreation visitor use in the general area is presently quite light with an estimated 50 visitor days and consists mainly of hunting (deer, rabbit and chukar partridge), rockhounding, and sightseeing. The bulk of this use is local in origin.

In addition to identified wildlife habitat values, the proposed Utah test-lease sites possess unique recreational value inherent in their relatively remote isolation from commercial development. Although the eastern portion of the lease unit is bisected by an unimproved county highway and a gilsonite transmission pipeline, the general area retains a basically primitive quality. The geologically dissected and eroded terrain has a scenic beauty enjoyed by many recreationists.

2.k.3 -- Recreation (Wyoming)

Tracts W-1 and -2 are situated in a remote, undeveloped area having semi-primitive characteristics. Although attractive for sport hunting, rock collecting, camping and general sight-seeing, recreational access is limited to dirt roads originating at surfaced highway (Interstate 80) approximately 25-30 miles to the north.

It is estimated that, despite the sparsity of surrounding human populations, and the absence of all-weather access, a total of several hundred man-days recreational use are expended annually within tract boundaries.

2.1.1 -- Archaeological and Historical Values (Colorado)

Tracts C-a and -b There are indications in the Piceance Basin that campsites of presently unknown nomadic hunting peoples, possibly Ute and older, will be encountered on the ridges above the valleys, in select caves and near water sources.

Farming activity along the main drainages preclude any surface indications of Indian activity. Gully erosion of some bottom land may expose evidence of early peoples.

Archaeological study of the tract areas has been very limited. The Midwest Archaeological Center, National Park Service, Lincoln, Nebraska; Colorado Historical Society, Denver, Colorado; and Department of Anthropology, Colorado University, Boulder, Colorado; have no record of known archaeological sites occuring on or near the tracts.

There are no historic sites listed for Rio Blanco County, Colorado, in The National Register of Historic Places.

Rio Blanco County has identified the Ryan Gulch school as a local historic site. This is a log cabin which lies adjacent to the route leading to site Tract C-a.

2.1.2 -- Archaeological and Historical Values (Utah)

Tracts U-a and -b A brief field reconnaissance and literature search indicates that there are archaeological and historical values near these sites.

The White River area in Utah has the highest values. Two rock overhangs with evidence of the Fremont culture, a farming group of Indians dating in the 11th Century A. D., were found within one-half mile of the White River at the County Bridge crossing and others may be expected along with possibly some pithouse village sites in the rest of the main canyon and near the mouths of the watered side canyons emptying into the White River.

Historical sites of importance are also present in the White River vicinity in the area immediately adjacent to the proposed use area. These are at the road crossing of the White River (Ignacio Stage Stop and Old Bridge) and in the Gilsonite mining area. The ghost towns of Rainbow and Watson, the remains of the narrow gauge Uintah Railroad which served the area until 1938 and the remains of many abandoned old gilsonite mines, an interesting relic of a rare mineral activity, are all adjacent to the south boundary of the development area. All of these sites are off the proposed lease areas.

There are no historic sites listed for Uintah County, Utah in the National Register of Historic Places.

The Colorado Historic Society recognizes the historic significance of the abandoned Uintah Railroad and related sites located along the Colorado - Utah State Line.

2.1.3 -- Archaeological and Historical Values (Wyoming)

Tracts W-a and -b The Kinney Rim area is in the heart of the historic Wind River Shoshone and Commanche country. Indications are that campsite and animal kill sites will be found in the area dating from present to historic times back some 10,000 years or more.

There are presently no known archaeological or historic sites on the tracts.

The National Register of Historic Places lists no sites in Sweetwater County Wyoming.

2.m.1 -- Land Use and Improvement (Colorado)

Tract C-a This site is utilized for several extensive land use activities including livestock grazing, use by several species of wildlife, wild horses, and a variety of recreation uses.

An unimproved truck trail runs through the site along a ridge between Boxelder Gulch and Corral Gulch. Unimproved truck trails also extend part way up Boxelder Gulch and Corral Gulch and deadend on the site.

There are several small stock water reservoirs and livestock control fences on the site and four rudimentary frame buildings that are used seasonally as a hunter camp.

Tract C-b This site is utilized for several extensive land use activities including livestock grazing, use by several species of wildlife and a variety of recreation uses.

Unimproved truck trails pass through the site along the West Fork of Stewart Gulch, along Scandard Gulch, and along a ridge top immediately east of Scandard Gulch.

The only other man-made improvements on the site are livestock control fences and small livestock water reservoirs.

2.m.2 -- Land Use and Improvements (Utah)

Tracts U-a and -b The proposed oil shale lease area is utilized for several extensive land use activities including a variety of types of outdoor recreation, grazing by sheep and several species of wildlife.

An improved unsurfaced county road passes through the northeast corner of Site U-b. An unimproved truck trail passes through both tracts connecting the county road in the northeast corner of Site U-b with an unimproved road running along West Fork Asphalt Wash.

A Gilsonite slurry pipeline and an electric power line run through sections 12, 18, and 19 of Site U-b in a northwest to southeast direction from Bonanza to Fruita, Colorado, and Grand Junction, Colorado, respectively.

Two small collection gas pipelines are located in Southam Canyon in Site U-a.

A woven wire sheep holding corral is situated near the northwest corner of section 24 in Site U-b and a small cattle handling corral is located in Southam Canyon in southwest quarter section 21 in Site U-a.

2.m.3 -- Land Use and Improvements (Wyoming)

Tracts W-a and -b Historically and currently the land has been and is used for grazing and hunting. These uses are outlined under livestock grazing and the wildlife portions of this report. The number of people visiting the area for purposes of rock collecting or scenic values is low. No creeks or streams, however, are located within the nominated sites.

An unimproved road passes through the northern end of Site W-a in a southwest to northeast direction. There are no other man-made improvements on either Site W-a or W-b. Carson Spring, a developed livestock watering facility is situated near the previously mentioned road approximately 3/4 mile northeast from Site W-a.

3. Impact of the Proposed Action

3.a. Mining, Processing and Waste Disposal Methods

Development and Production Schedules

Starting with the issuance of leases in early 1973, three to four years are required for detailed investigations for design of mining plans and environmental controls, for demonstration unit and prototype plant construction and operation. Engineering design of the first commercial 50,000 - 100,000 bbl/cd unit is assumed to begin during the year of prototype plant operation. Construction would be started six months after completion of prototype plant operation to provide time for inclusion of desirable modifications and for final review of the project. A 2-1/2 to 3 year construction period can be assumed.

With this schedule of development, the first commercial unit would start up about 1978 or 1979. The logistics of technical manpower, training and equipment availability are anticipated as inhibiting development and construction of additional units during a 10-year period except for units on the more favorable private lands.

Development Technology

Based upon presently available technology, three possible methods are considered for the extraction of shale oil. They are (1) surface (open pit) mining and surface processing; (2) underground mining and

surface processing; and (3) in situ methods. An example of open pit mining similar to one that might be used for oil shale is shown in Figure 1. A typical underground room and pillar mine is shown in Figure 2. A possible in situ recovery method is shown in Figure 3. For in situ methods chemical explosives or other methods other than nuclear might be used for fracturing the rock.

Probable Environmental Effects of Mining, Processing, and Waste Disposal Methods

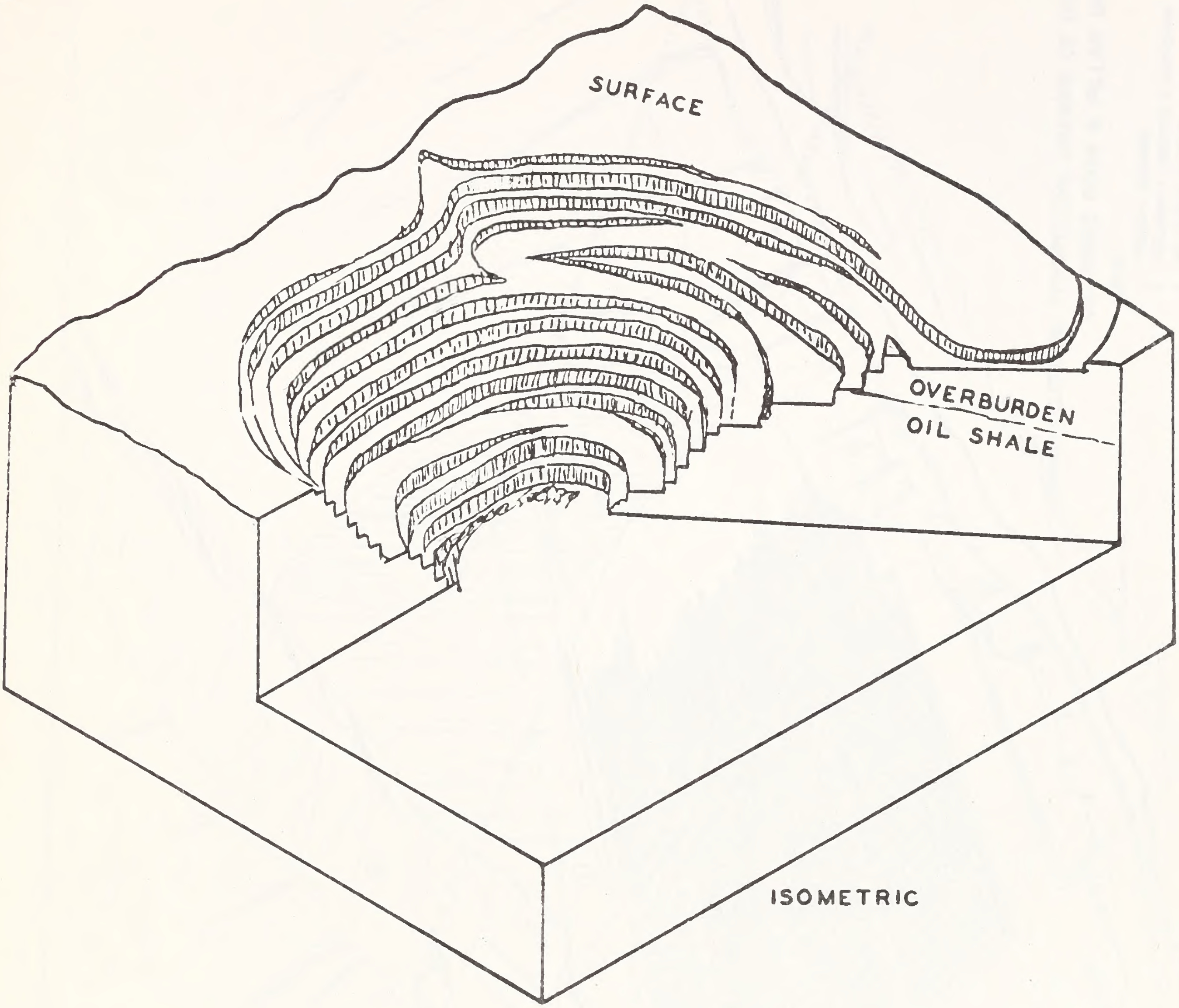
In the following discussion, technical assumptions and various options are presented for each of the selected tracts and their probable impact upon the environment is estimated in terms of land area requirements for mining, disposal of overburden, processed shale, and excess water, employment, water sources for processing, electrical power sources, pipelines, storage of crude shale oil, and access roads.

Because the number of employees will be the same for a selected mining method, regardless of the selected tract, the following estimated employment figures apply to any tract.

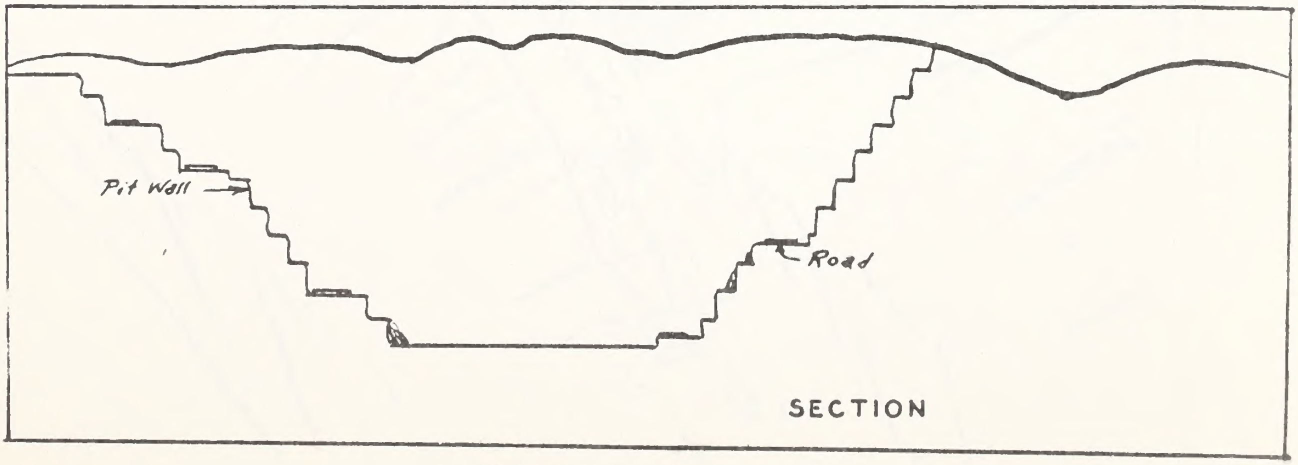
Surface (Open Pit) Mining and Surface Processing (100,000 barrels per day production). -

Employment: During the initial three-year term of the lease, an estimated 200 employees will be required for additional field

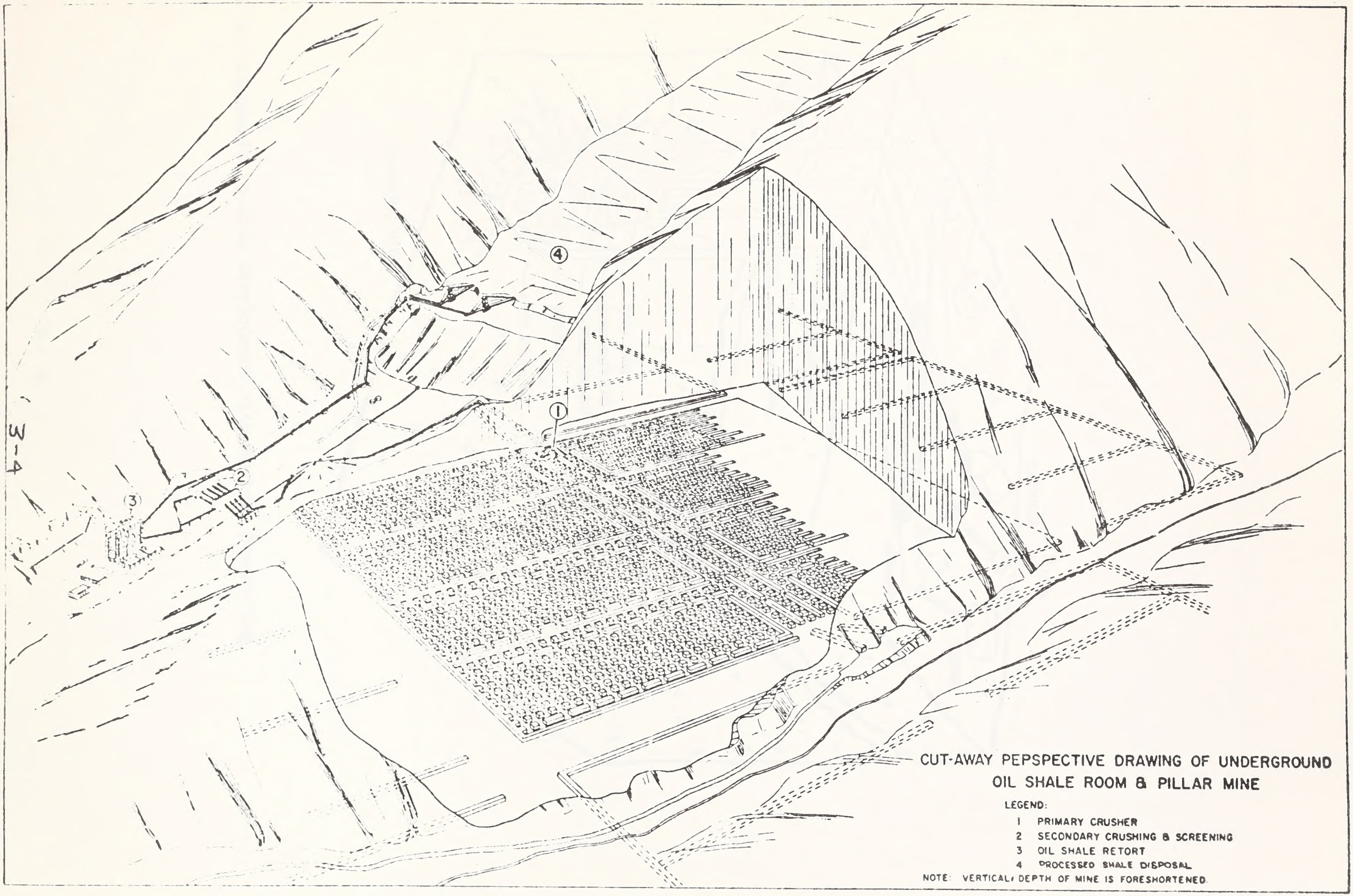
FIGURE 1. - SCHEMATIC OPEN-PIT DEVELOPMENT



ISOMETRIC



SECTION



CUT-AWAY PEPSPECTIVE DRAWING OF UNDERGROUND OIL SHALE ROOM & PILLAR MINE

LEGEND:

1 PRIMARY CRUSHER
2 SECONDARY CRUSHING & SCREENING
3 OIL SHALE RETORT
4 PROCESSED SHALE DISPOSAL

NOTE: VERTICAL, DEPTH OF MINE IS FORESHORTENED.

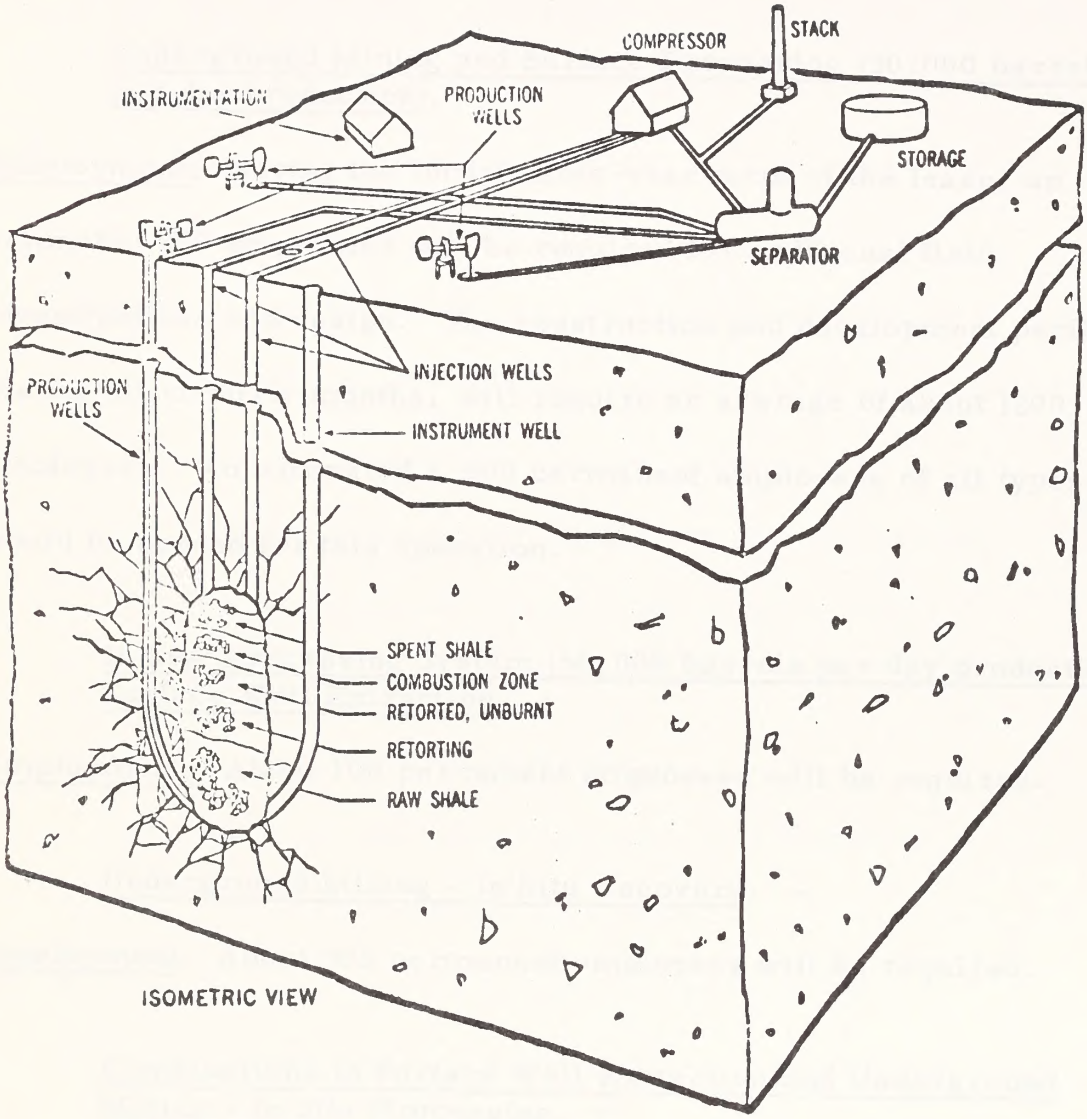


FIGURE 3. -**Schematic In-Situ Development with Nuclear Fracturing**

investigations and design. The construction and development period, lasting about thirty-six months, will require an average of about 1200 employees with a peak of about 1700. Approximately 800-1000 permanent employees will be required.

Underground Mining and Surface Processing (50,000 barrels per day production). -

Employment: During the initial three-year term of the lease, an estimated 200 employees will be required for additional field investigations and design. The construction and development period, lasting about thirty months, will require an average of about 1200 employees. An estimated 1,000 permanent employees of all types would be needed for this operation.

In Situ Processing System (50,000 barrels per day production), Surface Well Extraction. -

Employment: About 100 permanent employees will be required.

Underground Mining - In Situ Recovery. -

Employment: About 300 permanent employees will be required.

Combinations of Surface Well Extraction and Underground Mining - In Situ Processing. -

Employment: About 200 permanent employees will be required.

3.a.1. Colorado

Colorado Tract C-a

Tract C-a is one of 2 selected tracts chosen for leasing under The Prototype Oil Shale Leasing Program.[1] Available technical information and the most likely method (s) for mining, processing and waste disposal for this tract are described below so that their probable environmental impact can be evaluated.

Three technical options are considered for extraction of shale oil (and possible associated minerals) from this tract. These are (in order of preference, based on available technology):

A. Surface (open pit) mining and surface processing.

B. Underground mining and surface processing.

C. In Situ recovery by

  (1) Surface well extraction

  (2) Underground mining - in situ processing

  (3) Combinations of (1) and (2).

A. Surface (open pit) mining and surface processing.

This method involves the excavation (stripping) and disposal of overburden, mining of the oil shale and associated minerals, processing, disposal of processed shale, disposal of excess water (if any) produced in the open pit, and restoration of the mined-out areas.

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[1] Program Statement for the Proposed Prototype Oil Shale Leasing Program, U.S. Dept. of the Interior, June 1971.

Technical Assumptions

(1) Production rate: 100,000 bpd shale oil (after 4th year of operation)

168,000 tpd raw shale

Total: 4.75 Billion Barrels — 134,400 tpd processed shale

(2) Land area requirements:

Facilities = 150 acres
Mine = 4970 acres
Total: 5120 acres

(3) Estimated water requirements: 2 bpd per 1 bpd shale oil produced

(4) Overburden Disposal: Overburden will probably be stacked on the surface, offsite, until sufficient pit area has been mined out to permit backfilling with overburden.

Total Overburden: 7.4 billion tons (4.9 billion c.y.)
Overburden Disposal Offsite: 600 million c.y.
Land Area Required: 1,000 acres

(5) Processed Shale Disposal:

Total Processed Shale: 6.39 Billion Tons (5.9 Billion c.y.)

Two Technical options are considered for processed shale disposal:

(1) Disposal offsite in canyons west of Cathedral Bluffs

Land Area Required: 12,500 acres

(2) Disposal offsite until sufficient pit area is available and then backfill into mined-out area of pit.

Disposal offsite: 264 million c.y.

Land Area required: 450 acres

(6) Disposal of Excess Water: Estimates of the amount of water that would be pumped from a large open pit mine range upward from a minimum of 13,465 GPM per square mile of mine area. Some of the water will be potable, but much of it will be saline.

Excess potable water presents no environmental problem. It would be discharged into the surface drainage. Excess saline water would have to be disposed of in a manner that would not have an adverse effect upon the environment.

(7) Water source for processing: No outside water will be required. Assume water sufficient for oil shale processing and for waste disposal will be available from the groundwater the surface mine will encounter. Assume that any excess water will be reinjected into its component aquifers.

(8) Power requirements and source: Electrical power would be available for the site from an existing power line near the confluence of Piceance Creek and White River, or at convenient points west of Cathedral Bluffs toward Rangely.

(9) Oil pipeline: A pipeline from the site to an existing line at Rangely, Colorado, will be required to transport the crude oil.

(10) Storage: Storage of the crude oil produced will probably be in steel vessels above ground and require an on site area of about 80 acres.

(11) Roads: Rifle would serve as the railhead. Access to the site will be from the Piceance Creek road to Ryan Gulch; thence south and west some seven miles on the Ryan Gulch road; then north and west to the 84 Ranch; and from this point, west to the mine site. Widening, paving and straightening of some 15 or 16 miles of road will be required. Alternate routes may be developed from the Douglas Creek road which would provide more direct access to Grand Junction.

B. Underground Mining and Surface Processing.

Field testing has demonstrated the feasibility of the room-and-pillar method for mining oil shale in the Mahogany Ledge. Methods for mining the lower zone will have to be developed. Percent extraction per panel should be at least 60 percent in the upper beds, decreasing with depth of mining. Overall extraction is estimated to be about 50 percent. Water may present a problem. Access would be by vertical or inclined shafts. Backfilling of the mined-out portions of the mine with processed shale is recommended to improve the stability of the mine structure, to reduce surface subsidence, and to reduce the amount of waste placed on the surface.

Technical Assumptions

(1) Production rate: 50,000 bpd shale oil (after the 4th year of operation)
74,800 tpd raw shale
59,800 tpd processed shale

(2) Land area requirements: Facilities = 100 acres

(3) Water requirements: 2 bbl water/bbl shale oil

(4) Processed Shale Disposal

Total processed shale: 3.2 billion tons (2.9 billion c.y.)

Three technical options are considered for disposal:

(1) Disposal offsite in canyons west of Cathedral Bluffs.
Land area required: 6,250 acres

(2) Disposal on site.
Land area required: 7,400 acres[1]
(assuming a surface dump 250 ft in height)

(3) Disposal of 60 pct in mined-out areas underground and 40 pct on surface.

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[1] Greater than size of tract.

During first 3 years, all processed shale would be disposed on surface until sufficient mined-out space was available.

Land area required: 100 acres

During remaining productive life of mine, 40 pct of the processed shale would be disposed on surface.

Land area required: 2,960 acres (includes original 100 acres)

(5) Disposal of excess water: Similar to open pit option.

(6) Water source for processing: No outside water will be required. Assume water sufficient for oil shale processing and for waste disposal will be available from the groundwater pumped from the mine. Assume that any excess water will be reinjected into its component aquifers.

(7) Power requirements and source: Electrical power would be available for the site from an existing power line near the confluence of Piceance Creek and White River, or at convenient points west of Cathedral Bluffs toward Rangely.

(8) Oil Pipeline: A pipeline from the site to an existing line at Rangely, Colorado, will be required to transport the crude oil.

(9) Storage: Storage of the crude oil produced will probably be in steel vessels above ground and require an on site area of about 40 acres.

(10) Roads: Rifle would serve as the railhead. Access to the site will be from the Piceance Creek road to Ryan Gulch; thence south and west some seven miles on the Ryan Gulch road; thence north and west to the 84 Ranch; and from this point, west to the mine site. Widening. paving and straightening of some 15 or 16 miles of road will be required. Alternate routes may be developed from the Douglas Creek road which would provide more direct access to Grand Junction.

C. In Situ Processing System

In situ retorting of oil shale contemplates removal of oil from the shale by beating the shale while it is underground. Various means of supplying or creating heat have been proposed. A number of experiments attempting to conduct in situ retorting through wellbores from the surface have been investigated through field experiments during the past 20 years by both industry and government. Two major problems so far with this approach are: (1) Having sufficient naturally occurring or artificially induced permeability to allow passage of gases and liquids, and (2) remotely controlling the process through wellbores from the surface.

Proposed sources of heat include underground combustion, heated natural gas or carbon dioxide gas, superheated steam, hot solvents, and combinations of the above. Besides surface wellbores, other proposed paths for introducing heat underground include mine shafts, tunnels, and fractures created by a variety of techniques. However, although preliminary results warrant additional research on the technique, a commercial in situ processing system has yet to be demonstrated.

(1) Surface well extraction

Heat would be introduced underground through surface wells and the oil recovered from the shale by heating it in place. Oil would be extracted from surface walls.

Technical Assumptions

(1) Production rate: 50,000 bpd of shale oil (after 4-6 years of operation)

(2) Land area requirements: Facilities = 43 acres

(3) Water requirements: 2 bbl water/1 bbl shale oil

(4) Processed shale disposal: None

(5) Excess water disposal: Saline water would have to be disposed of in a way that would not have an adverse effect upon the environment.

(6) Water requirements for processing: No outside water will be required. Assume water sufficient for oil shale processing and for waste disposal will be available from the groundwater the surface wells will encounter. Assume that any excess water will be reinjected into its component aquifers.

(7) Power requirements and source: Electrical power would be available for the site from an existing power line near the confluence of Piceance Creek and White River, or from convenient points west of Cathedral Bluffs toward Rangely.

(8) Oil pipeline: A pipeline from the site to an existing line at Rangely, Colorado, will be required to transport the crude oil.

(9) Storage: Oil storage facilities for the crude oil produced will require about 40 acres. Storage will be in steel tanks above ground.

(10) Roads: Rifle will serve as the railhead. Access to the site will be from Piceance Creek road to Ryan Gulch; thence south and west some seven miles along the Ryan Gulch road; thence north and west to the 84 Ranch; thence west to the mine site. A new heavy duty bridge will be required across Piceance Creek. Widening, paving and straightening of some 15 to 16 miles of road will be required. Alternate routes may be developed from the Douglas Creek road which would provide more direct access to Grand Junction.

(2) Underground mining - in situ recovery

This proposed method involves the mining of a small portion of oil shale to provide void space, the subsequent fracturing by explosives to provide permeability, and the heating of the fractured shale in situ. The small portion of mined shale would be processed on the surface.

Technical Assumptions

(1) Production rate:	50,000 bpd shale oil (after 4th year of operation) 5,000 tpd raw shale 4,000 tpd processed shale

(2) Land area requirements: Facilities = 48 acres

(3) Water requirements: 2 bbl water/1 bbl shale oil

(4) Processed Shale Disposal:

Total processed shale: 379.6 million tons (349.2 million c.y.)

Disposal on site

Land area required:
(assuming a surface dump
250 ft. in height 900 acres

(5) Disposal of excess water: Similar to surface well extraction

(6) Water requirements for processing: No outside water will be required. Assume water sufficient for oil shale processing and for waste disposal will be available from the groundwater the mine will encounter. Assume that any excess water will be reinjected into its component aquifers.

(7) Power requirements & source: Electrical power would be available for the site from an existing power line near the confluence of Piceance Creek and White River, or from convenient points west of Cathedral Bluffs toward Rangely.

(8) Oil pipeline: A pipeline from the site to an existingline at Rangely, Colorado, will be required to transport the crude oil.

(9) Storage: Crude shale will be stored in steel tanks on the surface. Oil space requirements will be about 40 acres.

(10) Roads: Rifle will serve as the railhead. Access to the site will be from the Piceance Creek road to Ryan Culch; thence south and west some seven miles along the Ryan Bulch road; thence north and west to the 84 Ranch; thence west to the mine site. A new heavy duty bridge will be required

across Piceance Creek. Widening, paving and straightening of some 15 to 16 miles of road will be required. As analternate, routes may be developed from the Douglas Creek road which would provide a more direct connection with Grand Junction.

(3) Combinations of surface well extraction and underground mining in situ processing.

Technical Assumptions

(1) Production rate: 50,000 bpd of shale oil (after 4th year of operations)
2,500 tpd raw shale
2,000 tpd processed shale

(2) Land area requirements: Facilities - 48 acres

(3) Water requirements: 2 bbl water/1 bbl shale oil

(4) Processed shale disposal: An estimated 50% of the processed shale under (b) would be produced.

Disposal on site: 450 acres

(5) Disposal of excess water: Similar to surface well extraction method.

(6) Water requirements for processing: No outside water will be required. Assume water sufficient for oil shale processing and for waste disposal will be available from the groundwater the mine will encounter and from surface wells. Assume that any excess water will be reinjected into its component aquifers.

(7) Power requirements & source: Electrical power would be available for the site from an existing power line near the confluence of Piceance Creek and White River, or from convenient points west of Cathedral

Bluffs toward Rangely.

(8) Oil pipeline: A pipeline from the site to an existing line at Rangely, Colorado, will be required to transport the crude oil.

(9) Storage: Crude shale oil storage will require about 40 acres for steel tanks on the surface.

(10) Roads: Rifle will serve as the railhead. Access to the site will be from Piceance Creek road to Ryan Gulch; thence south and west some 7 miles along the Ryan Gulch road; thence north and west to the 84 Ranch; thence west to the mine site. A new heavy duty bridge will be required across Piceance Creek. Widening, paving and straightening of some 15 to 16 miles of road will be required. An alternate route, that would provide a more direct access to Grand Junction, may be developed from Douglas Creek.

Tract C-b

Tract C-b is one of the two selected tracts chosen in Colorado for leasing under The Prototype Oil Shale Leasing Program. Available technical information and the most likely method(s) for mining, processing and waste disposal for this tract are described below so that their probable environmental impact can be evaluated.

Two technical options are considered for extraction of shale oil (and possible associated minerals) from this tract. These, are in order of preference, based on current technology.

A. Underground mining and surface processing

B. In Situ recovery by

(1) Surface well extraction

(2) Underground mining - in situ processing

(3) Combinations of (1) and (2)

A. Underground mining and Surface Processing.

Field testing has demonstrated the feasibility of the room-and-pillar method for mining oil shale in the Mahognay Ledge. Methods for mining the lower zone will have to be developed. Percent extraction per panel should be at least 60 percent in the upper beds, decreasing with depth of mining. Overall extraction is estimated to be about 50 percent. Water may present a problem. Access would be by vertical or inclined shafts. Backfilling of the mined-out portions of the mine with processed shale is recommended to improve the stability of the mine structure, to reduce surface subsidence, and to reduce the amount of waste placed on the surface.

Technical Assumptions

(1) Production rate: 50,000 bpd shale oil
:74,800 tpd raw shale
:59,800 tpd processed shale

(2) Land area requirements: Facilities = 100 acres

(3) Water requirements: 2 bbl water/bbl shale oil

(4) Processed Shale Disposal

Total processed shale: 3.2 billion tons (2.9 billion c.y.)

Three technical options are considered for disposal:

(1) Disposal offsite in canyons.

Land area required: 6,250 acres

(2) Disposal on site.

Land area required: 7,400 acres[1] (assuming a surface dump 250 ft in height)

(3) Disposal of 60 pct in mined-out areas underground and 40 pct on surface.

During first 3 years, all processed shale would be disposed on surface until sufficient mined-out space was available.

Land area required: 100 acres

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[1] Greater than size of tract.

During remaining productive life of mine, 40 pct of the processed shale would be disposed on surface.

Land area required: 2,960 acres (includes original 100 acres)

(5) Disposal of Excess Water: There is no hydrologic information available from which to estimate the volume of water that would have to be pumped to permit underground mining or to permit any of the proposed methods for In Situ recovery. It is assumed some of the water will be potable but that the volume and salinity will increase with depth.

Excess potable water presents no environmental problem. It would be discharged into the surface drainage. Excess saline water would have to be disposed of in a manner that would not have an adverse effect upon the environment.

(6) Water Requirements and source: About 100,000 barrels/day of water, (55 gal/bbl), equivalent to 5-1/2 million gallons, approximately 17 acre feet.

Assume water available from White River by pipeline. There has been some talk of developing water in the Upper White River drainage and piping this water through the Hogback into Piceance Creek, and from Piceance Creek to the development site.

(7) Power requirements and source: Power would be available from existing high voltage power lines north and east of the site. It will be necessary to construct an additional high voltage power line. The nearest source is down Piceance Creek near the White River, a distance of about 18 miles. The alternate source to the east is about 15 miles distant.

(8) Oil Pipeline: Assume shale oil will move to refining centers via pipelines. Most probable route will be into existing pipeline at Rangely and thence to Salt Lake City, Utah. Another route is north to Wamsutter and Casper, Wyoming, thence to St. Louis, Missouri, markets. One other alternative may be via Denver into the Chicago, Illinois, refining area pipeline near Sterling, Colorado.

(9) Storage: Crude shale oil storage facilities will require approximately 40 acres for steel tanks on the surface.

(10) Roads: Access from Piceance Creek road is blocked by patented lands along the Creek bottom. BLM is attempting to gain access into Scandard Gulch. We should therefore assume access via this road. A heavy duty bridge will be required across Piceance Creek. It will be necessary to widen and pave the road.

B. In Situ Processing System

In situ retorting of oil shale contemplates removal of oil from the shale by heating the shale while it is underground. Various means of supplying or creating heat have been proposed. A number of experiments

attempting to conduct in situ retorting through wellbores from the surface have been investigated through field experiments during the past 20 years by both industry and government. Two major problems so far with this approach are: (1) having sufficient naturally occuring or artificially induced permeability to allow passage of gases and liquids, and (2) remotely controlling the process through wellbores from the surface.

Proposed sources of heat include underground combustion, heated natural gas or carbon dioxide gas, superheated steam, hot solvents, and combinations of the above. Besides surface wellbores, other proposed paths for introducing heat underground include mine shafts, tunnels, and fractures created by a variety of techniques. However, although preliminary results warrant additional research on the technique, a commercial in situ processing system has yet to be demonstrated.

The following items discussed under Underground Mining and Surface Processing also apply to In Situ Recovery.

(5) Disposal of Excess Water

(6) Water requirements for processing

(7) Power requirements and source

(8) Oil pipeline

(9) Storage

(10) Roads

(1) Surface well extraction

Heat would be introduced underground through surface wells and the oil recovered from the shale by heating it in place. Oil would be extracted from surface walls.

Technical Assumptions

(1) Production rate: 50,000 bpd of shale oil (after 4-6 years of operation)

(2) Land area requirements: Facilities = 43 acres

(3) Water requirements: 2 bbl water/1bbl shale oil

(4) Processed shale disposal: None

(2) Underground mining - in situ recovery

This proposed method involves the mining of a small portion of oil shale to provide void space, the subsequent fracturing by explosives to provide permeability, and the heating of the fractured shale in situ. The small portion of mined shale would be processed on the surface.

Technical Assumptions

(1) Production rate: 50,000 bpd shale oil (after 4th year of operation)
5,000 tpd raw shale
4,000 tpd processed shale

(2) Land area requirements: Facilities = 48 acres

(3) Water requirements: 2 bbl water/1 bbl shale oil

(4) Processed Shale Disposal:

Total processed shale: 379.6 million tons (349.2 million c.y.)

Disposal on site

Land area required:
(assuming a surface dump
250 ft in height) 900 acres

(3) Combinations of surface well extraction and underground mining in situ processing.

Technical Assumptions

(1) Production rate: 50,000 bpd of shale oil (after 4th year of operations)
2,500 tpd raw shale
2,000 tpd processed shale

(2) Land area requirements: Facilities - 48 acres

(3) Water requirements: 2 bbl water/1 bbl shale oil

(4) Processed shale disposal: An estimated 50 pct of the processed shale under (2) would be produced.

Disposal on site: 450 acres.

3.a.2. Utah

Tracts U-a and U-b were chosen in Utah for leasing under The Prototype Oil Shale Leasing Program. Available technical information and the most likely method(s) for mining, processing, and waste disposal for these tracts are described below so that their probable environmental impact can be evaluated.

Two technical options are considered for extraction of shale oil (no associated minerals have been reported) from these tracts. They are, in order of preference, based on current technology:

(A) Underground mining and surface processing.

(B) In situ recovery by

- (1) Surface well extraction
- (2) Underground mining - in situ processing
- (3) A combination of (1) and (2)

Surface (open pit) mining is not considered to be economic because of the overburden/ore ratio of the deposit.

A. Underground Mining and Surface Processing

Field testing has demonstrated the feasibility of the room-and-pillar system for mining oil shale in beds of about 100 ft thickness. The mines could be developed by vertical and/or inclined shafts. Percent extraction per panel should be about 60 percent. Overall extraction is estimated at about 50 percent. Back filling of the mined-out portions of the mine with the processed shale is recommended to improve the stability of the mine structure, to reduce surface subsidence, and to lessen the amount of solid waste disposed on the surface.

Since saline water has not been reported in the deposit, there should be no problem with disposal of excess mine water. It is assumed that water from the White River will be used to support the operation, If White River water is not available, the other source is the Green River which is about 25 miles from the tract.

Technical Assumptions for One Tract

(1) Production Rate: 50,000 bpd shale oil (after 4th year of operation

84,000 tpd raw shale

67,200 tpd processed shale

(2) Estimated land area required: Facilities - 100 acres

(3) Estimated water required: 2 bbl water/1 bbl shale oil

(4) Processed shale disposal

Total processed shale: 702 million tons (646 million cu yd)

Two technical options are considered for processed shale disposal:

(1) Disposal on site

Land area required (assuming a surface dump 250 ft high): 1650 acres.

(2) Disposal of 60 percent in mined-out areas underground and 40 percent on surface. During the first 3 years, while the underground mine is under development, solid waste would be stored on the surface.

Land area required: 100 acres

During the remaining life of the mine, 40 percent of the processed shale would be disposed on surface:

Land area required: 640 acres (including original 100 acres)

(5) Water requirements and source: The best estimate of water requirements is two barrels of water (55 gallon barrels) to one barrel of crude (42 gallons), or 100,000 barrels of water equivalent to 5-1/2 million gallons daily, approximately 17 acre feet.

The White River at the north edge of the site is the closest source of water if it is available. The only other source would be from the Green River, and that would have to be piped about 25 miles to this development site. Three points on the Green River are about this distance from the site. One is seven miles south of Jensen, Utah; another at the lower end of the Horseshoe Bend, and the other near Ouray, Utah. The Ouray point appears to be the best for pipeline construction.

(6) Power requirements and source: Existing power lines to Bonanza and the pumping station at the bridge on White River run near the site, but are probably inadequate for an oil shale plant in addition to their present load. It would be necessary to connect with the substation three miles west of Jensen, Utah. The Bureau of Reclamation and Moon Lake Electric have high voltage lines connected at this point.

(7) Oil pipeline: One of the crude oil pipelines connecting the Rangely and Red Wash fields to Salt Lake City passes south of Bonanza about six miles north of this site. Assume connection from the site to this line at a convenient point.

(8) Storage: About 40 acres is required to store crude shale oil in steel surface tanks.

(9) Roads: There is a paved state highway to Bonanza. From there it will be necessary to build eight miles of primary paved roads and a bridge across White River, plus any roads needed on the site.

B. In Situ Processing System

In situ retorting of oil shale contemplates removal of oil from the shale by heating the shale while it is underground. Various means of supplying or creating heat have been proposed. A number of experiments attempting to conduct in situ retorting through wellbores from the surface have been investigated through field experiments during the past 20 years by both industry and government. Two major problems so far with this approach are: (1) Having sufficient naturally occurring or artificially induced permeability to allow passage of gases and liquids, and (2) remotely controlling the process through wellbores from the surface.

Proposed sources of heat include underground combustion, heated natural gas or carbon dioxide gas, superheated steam, hot solvents, and combinations of the above. Besides surface wellbores, other proposed paths for introducing heat underground include mine shafts, tunnels, and fractures created by a variety of techniques. However, although preliminary results warrant additional research on the technique, a commerical in situ processing system has yet to be demonstrated.

The following items discussed under Underground Mining and Surface Processing apply equally well to In Situ Recovery and will not be further discussed.

(5) Water requirements and source

(6) Power requirements and source

(7) Oil Pipeline

(8) Storage

(9) Roads

(1) Surface well extraction

Heat would be introduced underground by surface wells and the oil recovered from the shale by heating it in place.

Technical Assumptions

(1) Production rate: 50,000 bpd of shale oil

(2) Estimated land area requirements: Facilities = 43 acres

(3) Estimated water requirements: 2 bbl water/bbl shale oil

(4) Processed shale disposal: None

(2) Underground mining - in situ recovery

This proposed method involves the mining of a small portion of oil shale to provide void space, the subsequent fracturing by explosives to provide permeability, and the heating of the fractured shale in situ. The small portion of mined shale would be processed on the surface.

Technical Assumptions

(1) Production rate: 50,000 bpd of shale oil
5,000 tpd raw shale
4,000 tpd processed shale

(2) Estimated land area requirements: Facilities - 48 acres

(3) Estimated water requirements: 2 bbl water/1 bbl shale oil produced

(4) Processed shale disposal:

Total processed shale: 42.3 million tons (38.9 million cu yd)

Disposal on site

Land area required:

(assuming a surface dump 250 ft high) 100 acres

(3) Combinations of surface well extraction and underground mining-in situ processing.

Technical Assumptions

(1)	Production rate:	50,000 bpd of shale oil 2,500 tpd raw shale 2,000 tpd processed shale
(2)	Estimated land area requirements:	Facilities - 48 acres
(3)	Estimated water requirements:	2 bbl water/1 bbl oil
(4)	Processed shale disposal:	An estimated 50% of the processed shale under (2) would be produced
	Disposal on site	
	Land area required:	
	(assuming a surface dump 250 ft high)	50 acres

3.a.3. Wyoming

Wyoming Tracts W-a and W-b

Tracts W-a and W-b have been chosen in Wyoming for leasing under The Prototype Oil Shale Leasing Program. Available technical information and the most likely method for mining, processing and waste disposal for these contiguous tracts are described below so that their probable environmental impact can be evaluated.

Only one technical option is considered for extraction of shale oil (no other minerals of value are known to be present) from these tracts.

A. In Situ recovery by

(1) Surface well extraction

(2) Underground mining - in situ processing

(3) Combinations of (1) and (2)

In Situ Processing System

In situ oil shale operations contemplate removal of the oil from the shale by heating the shale underground. This process would be basically the same at all sites and its concept is described under Colorado Tract C-a.

Surface operations are relatively small in scope for in situ recovery, and the problems associated with mining and spent shale disposal depend upon the in situ method used. In any case, in situ in any of its methods discussed here presents a minimal disturbance of the original land surface and vegetation.

(1) Surface well extraction

Heat would be introduced underground by surface wells and the oil recovered from the shale by heating it in place.

Technical Assumptions

(1) Production rate: 50,000 bpd of shale oil

(2) Land area requirements: Facilities = 43 acres

(3) Estimated water requirements: 2 bbl water/ 1 bbl shale oil produced.

(4) Processed shale disposal: None

(5) Disposal of Excess Water: There is no information available from which to estimate the volume of water that might have to be pumped from underground to permit or support the proposed methods for in situ recovery. It is assumed water (probably from the Green River) will have to be furnished to the site to support the operation. However, waste water from the mist plant is anticipated and this will have to be disposed of in a manner that would not have an adverse effect upon the environment.

(6) Water requirements and source for processing: Best estimate of water requirements is two (55 gallon) barrels water for each barrel of oil produced, or 100,000 barrels of water equivalent to 5-1/2 million gallons daily, approximately 17 acre feet. Assume water supply available from Flaming Gorge Reservoir, 45 to 50 miles from the tract.

(7) Power requirements and source: Electrical power would be available from established power lines north of the Washakie Basin supplying the Patrick Draw oil and gas field. Another source of power could be from the yet to be completed Jim Bridger Steam-Electric Plant. Purchase of energy from this source would have to be negotiated with Pacific Power and Light Co. The plant is believed to be designed to produce 34KUW of power with a transmission line running parallel to Highway I-80.

(8) Oil pipeline: A pipeline tie-in could be made with the existing line from Patrick Draw oil field 33 miles to the northeast of each tract.

(9) Storage: Storage of the crude oil produced will probably be in steel vessels above ground and will require an onsite area of about 40 acres.

(10) Roads: Wyoming State Highway 430 will need widening and resurfacing to accommodate heavy equipment traffic. The dirt access road from Highway 430 into the sites would have to be paved to make it an all weather road.

(2) Underground mining - in situ recovery

This proposed method involves the mining of a small portion of oil shale to provide void space, the subsequent fracturing by explosives to provide permeability, and the heating of the fractured shale in situ. The small portion of mined shale would be processed on the surface.

Technical Assumptions

(1) Production rate: 50,000 bpd shale oil
5,000 tpd raw shale
4,000 tpd processed shale

(2) Land area required: Facilities = 48 acres

(3) Estimated water requirements: 2 bbl water/1 bbl shale oil produced

(4) Processed Shale Disposal:
Total processed shale: 379.6 million tons (349.2 million c.y.)
Disposal on site
Land area required:
(assuming a surface dump
250 ft in height) 900 acres

Items (5 through (10) would be basically the same as for the surface well extraction method.

(3) Combinations of surface well extraction and underground mining - in situ processing.

Technical Assumptions

(1) Production rate: 50,000 bpd of shale oil
2,500 tpd raw shale
2,000 tpd processed shale

(2) Land area requirements: Facilities = 48 acres

(3) Estimated water requirements: 2 bbl water/1 bbl shale oil produced.

(4) Processed shale disposal: An estimated 50 pct of the processed shale under (2) Underground mining - in situ recovery, would be produced.

Disposal on site: 450 acres

Items (5) through (10) would be similar to Surface Well Extraction Methods.

3.b.1 Water Resources (Colorado)

The environmental impact of the proposed action

Consideration of tract features

Tract No. C-a - This tract has a relatively thin layer of overburden and is well suited to open-pit mining. A large open-pit mine will intercept the channels of Box Elder and Corral Gulches and will penetrate the saturated ore of the upper part of the leached zone. It is estimated that from 15 to 50 cfs of ground water will have to be pumped from the mine to keep it dewatered and workable. Surface streams will have to be diverted around the mine to prevent flooding of the pit.

The first ground water to be encountered during the excavation will contain considerable less than 1,000 mg/l of dissolved solids, but as the excavation goes deeper, water will be encountered with dissolved-solids concentrations as much as 1,500 to 2,000 mg/l. A sizable cone of depression will develop around the pumped mine, and there is a possibility that moderately or very saline water from greater depths in the leached zone will move upward into the mine.

If the open-pit mining operation reaches its full expected capacity of 100,000 barrels per day, the retorting operation will require process water amounting to about 11 million gpd (gallons per day) or 17 cfs. It is not presently known if the process will be able to tolerate 1,000 mg/l or more of dissolved solids. In the event that 1,000 mg/l or more is tolerable, and that more saline water will not be drawn into the mine, the dewatering process could supply the process needs. Indeed, it may supply water for use on other tracts. If the saline water is intolerably salty, the operation will be faced with the dual problem of waste water disposal and water supply. It will be necessary to use storage facilities on the White or Colorado Rivers, and to import the water to the site through ditches or buried pipelines. Ice undoubtedly will hinder transport via ditches, and buried pipelines may be necessary.

If saline water withdrawn from the mine cannot be used in the retorting process, enforcement of the Environmental Protection Agency's nondegradation policy will certainly prohibit discharge into streams and treatment or reinjection would then seem mandatory. The lower part of the leached zone is a likely place to inject waste water, but there are possibilities that injection will disturb the movement of the saline ground waters and may possibly make the upper portion of the leached zone more salty and increase probability of seismic activity.

Disposal of process waters presents the same problems as does disposal of dewatering water. If the waters can be treated to meet the quality standards of the State of Colorado they might be discharged to the streams to be put to beneficial use downstream. Alternately, if they cannot be treated or can be treated only at prohibitive expense, subsurface disposal is one of the two alternatives and evaporation ponds is the other alternative.

Subsurface disposal of dewatering water or process waste water may seem to be a simple solution to a difficult problem, but many possible environmental effects may result. The rates of movement and mixing of saline ground waters are poorly understood, and many potential problems may result. Methods exist by which the effects of injection can be predicted with reasonable accuracy using mathematical models, but at the present time such modeling has not been done, and sufficient data are not available to make a good predictive model.

Waste water, either from processes or dewatering, will increase channel erosion if the waters are discharged into streams. These wastes could possibly increase the mean flow of the small tributaries and will increase the annual sediment load by cutting material from the streambeds and banks.

Sediment problems in the streams near the site may result from several processes related to the construction and operation of an open-pit mine at tract C-a including: (1) disposal of spent shale, (2) disposal of overburden, (3) storage of crushed shale, (4) plant construction, and (5) road and pipeline construction. Precipitation at the rate of about 1 inch in 24 hours occurs at the site about once each year; more than 3 inches of precipitation has been known to fall within 24 hours in the vicinity; and the maximum probable 24-hour precipitation is estimated to be more than 10 inches. Rains of 1 inch would wash considerable quantities of sediment from piles of crushed or spent shale or overburden, or from land surfaces left barren during construction.

Spent shale probably will be transported from the retorting site as a slurry. Water pumped from the mine probably will be used to transport the shale, and a significant part of this water might run into streams or seep into the aquifers. Surface runoff undoubtedly will carry suspended sediment. Data are not available for predicting the chemical quality of the water owing to materials leached from the shale, but undoubtedly it will contain measureable amounts of dissolved materials.

Storage tanks and pipelines at the retorting facility offer a potential for stream pollution. Failure of one of the tanks or lines could release large volumes of oil into the streams or aquifers. If a failure takes place during a rainstorm or during a time of heavy snowmelt runoff, little time will be available for corrective action before the oil reaches the stream or is soaked into the ground. The risk here, however, is no greater than at other sites where oil is conveyed or stored.

Assuming an employment of about 1,300 employees at the site, it is estimated that the water needs of these employees and their families will be about 800,000 gpd, or about 1.2 cfs. High-quality water will be required for domestic use, and this will be in addition to the water provided for the existing populations in the communities in which the employees will live. Waste disposal facilities also will be required to handle the load from about 5,000 persons. If 200 employees live on the tract, about 160,000 gpd will have to be supplied to meet their needs, and waste treatment facilities also will be required.

The above predictions of environmental impact have assumed that the oil shale at site C-a will be developed by open-pit mining, as proposed in the site-nomination documents. It also is possible that the site may be developed using underground mining or in situ processing. In the event one of these other processes is used, oil production and water requirements will be only about one-half of the amounts estimated for open-pit mining. The same general discussions apply to providing water as applied for the open-pit process; however, of course, ground water will have to be developed using wells rather than from pumping from the pit. Dewatering of the underground mine or in situ site also will be required. Disposal of the dewatering water will present the same sort of problem as does disposal from an open pit, but the volume will be considerably smaller.

Overburden storage will be a much smaller problem if underground mining or in situ development is used. Crushed shale storage and spent shale disposal will not be present with in situ development, but with underground mining there will be problems similar to those expected with open-pit mining.

In situ development potentially will cause problems of ground-water contamination from the retorting process and from shale left in place. It is difficult to judge either the type or the severity of these problems until the details of the processes are known, or possibly until the prototype operation begins.

Tract No. C-b --Conventional underground mining, using a room and pillar method, is most likely to be employed at tract C-b. Such a method is expected to produce oil at the rate of about 50,000 barrels per day and will require processing water at the rate of about 5.5 million gpd (8.5 cfs). This amount of water might be developed in the alluvium along Piceance Creek or in the upper part of the leached zone of the Green River Formation provided that problems of water-right infringements caused by stream depletion could be solved. Solving the water rights problem would involve the purchase of water rights from senior holders, or an arrangement to substitute waste water or imported water of satisfactory quality for the water removed for shale processing. There also is the possibility that pumping from the upper part of the leached zone will result in intrusion of moderately or very saline water from the lower part of the zone. This possibility can be predicted using presently known modeling techniques, but at the present time, the modeling has not yet been done, and avilable data probably are inadequate for accurate modeling.

In the event that adequate amounts of water of good quality cannot be developed on the tract, it will be necessary to go to sources on the White or Colorado Rivers, and to import about 8.5 cfs by buried pipeline.

Mining operations will penetrate the aquifers of the Green River Formation and dewatering of the mine will be a serious problem. Volumes are hard to estimate, but from 10 to several tens of cubic feet per second might be expected. Water from the shallow part of the leached zone might be put to use as process water, but water from the deeper parts of the leached zone will be extremely salty and will present a disposal problem. Reinjection of waste water into the lower parts of the leached zone seems to be the only possible means of disposal of the highly saline water or untreated processing water, but the practice may result in unwanted shifts of the fresh-salt water boundary, and increased probability of seismic activity. Detailed hydrologic modeling could help predict the movement of the reinjected waste water. In addition to the above mentioned problems, it must be remembered that mine dewatering is likely to reduce the artesian pressure along Piceance Creek and deplete streamflow, injuring the water rights of senior holders.

Disposal of dewatering or waste waters into streams is likely to cause channel erosion problems. Erosion could be quite serious if the waterways of the smaller tributaries are chosen as disposal sites, but erosion probably would be a less serious problem if the waste waters were discharged directly into Piceance Creek, a perennial stream.

As discussed in the earlier description of other tracts, potential erosion and sediment pollution problems exist from storage of overburden, spent shale, and crushed shale, and from plant, roadway, and pipeline construction. The reader is referred to the discussion for tract C-a for a more detailed discussion of this problem. Quantitative predictions of the amount of erosion cannot be made here, but the magnitude of the problem could be considerable if suitable control measures are not affected.

After mining by the room and pillar method has progressed sufficiently, spent shale can be disposed of by backfilling of the mine. Potential groundwater contamination problems may arise from materials leached from the shale. There is inadequate knowledge at the present time to quantitatively predict the amounts or types of material that may be leached from the shale by the ground water that it contacts. An additional problem may arise from contamination by the water used to form the slurry that is pumped into the mine.

Surface subsidence is a potential problem in any mining operation, and must be considered in view of the hydrology of the basin. Subsidence often directly affects drainage patterns by altering the slope of streams. However, at this site the stream channels have a considerable slope, and subsidence effects are not expected to be severe. Backfilling of the mines with spent shale will help prevent subsidence problems.

Stream and ground-water pollution from accidentally spilled oil must be considered, as they have been for other tracts. A most critical problem is likely to occur if a pipeline or tank failure coincides with a period of rain or snowmelt. With water to help transport the spilled oil it quickly will be transported into the high-quality shallow aquifers and into the streams.

It has been estimated that about 1,000 employees will be required to operate the mine and retorting facility at tract C-b. The reader is here referred to the discussion of population impact on water supply and waste that was presented for site C-a. Tract C-a has about the same personnel requirements as does tract C-b, and the water needs and waste loading from the populations can be expected to be about the same.

Although this discussion has treated subsurface mining as the probable method of development of tract C-b, the site also is suited to development by in situ methods. Problems of water supply, dewatering, and waste water disposal will be about the same as described for subsurface mining. Only very small amounts of overburden and spent shale will be disposed of on the surface. Only about one-tenth as many employees will be required for the in situ operation as are required for subsurface mining, therefore, the need to supply water and provide waste treatment will be greatly diminished.

In-situ development potentially will cause problems of ground-water contamination from the retorting process and from shale left in place. It is difficult to judge either the type or the severity of these problems until the details of the processes are known, or possibly until the proto-type operation begins. Further discussion of environmental problems in water resources caused by in-situ development is presented with the evaluation of site U-a where the in-situ process is most likely to be employed.

3.b.2 Water Resources (Utah)

Tract No. U-a - It is expected that this site will be developed as a pilot in-situ operation, or be developed in two sections, one in-situ and the other conventional mining by the room and pillar method.

At full production the in-situ operation may produce as much as 50,000 barrels of oil per day and require 5.5 million gallons of water per day (8.5 cfs). This water might be supplied from a relatively shallow part of the aquifer, but more likely it will be necessary to use surface water from the White River.

Information on water rights is not available, but it is assumed that water rights on the White River are fully used and that the oil shale development will have to purchase rights from other users. A pipeline 4 or 5 miles long will be required to bring the required 8.5 cfs from the White River to the point of operation on tract U-a.

Details of the in-situ process are not known, but it is assumed that dewatering of the working area will be required. Water to be removed is expected to have a dissolved-solids concentration of as much as 3,000 mg/l, which would prohibit disposal by discharge into streams. However, the volume to be removed is expected to be relatively small compared with the volume pumped from other types of mines and reinjection of waste water seems to be a workable solution to the problem. If the volume of water to be removed turns out to be substantially great, the dewatering may affect the flow of ground water to the White River, or even divert water from the river. The possibility of salt-water intrusion also exists, and can be accurately predicted with the help of a detailed mathematical model and much more data on the characteristics of the aquifer.

Process water also must be disposed of. Any scheme other than complete recycling will have some environmental effects. If the water is to be discharged to streams it must meet Utah water-quality standards. The flow path of injected water cannot be predicted without detailed knowledge of the injection site and model studies.

Spent shale from the in situ process will be left in place, and therefore will not present the surface erosion and chemical leaching problem that is present from surface disposal. However, leachate introduced into the ground water is expected to affect the quality of ground water, but the amount and manner cannot be predicted. More laboratory and experimental studies, as well as field monitoring of a prototype site will be necessary before leaching effects can be predicted.

Depending upon the type of process to be used, ground contamination also can result during the in situ extraction process. Certain solvents and gases that are injected into the aquifer or released by the retorting kerogens may escape into the aquifers if pressure conditions are favorable. A careful reevaluation of the environmental impact of in situ processing should be made when the process to be used is clearly defined when the exact site of the prototype operation is known and when characteristics of the aquifers are better defined by field exploration.

Stream sedimentation problems can be expected from materials eroded during plant, roadway, and pipeline construction. Most of the erosion will take place during periods of snowmelt and runoff from thunderstorms. Additional stream sediment problems will occur as stream bottom and bank cutting caused by the disposal of process and dewatering waste water into small waterways. If the wastes are discharged directly into the White River, cutting effects will be minimal because of the larger natural flow of the River.

Surface-water and ground-water pollution may result from spillage of oil or breakdown of treatment or waste injection facilities. Spillage could occur as a result of pipeline or storage tank rupture and would be worse if the spill took place during snowmelt periods or thunderstorms.

An in situ operation, after construction was completed, would employ about 100 people. This small increase in the area's population would cause minimal demands on the water supply and waste disposal facilities in nearby communities.

If tract U-a is developed by underground mining rather than by in situ extraction, environmental effects may be somewhat different from those predicted above. Particularly, storage of crushed shale and disposal of spent shale will become important factors to consider. An underground mining operation will require considerably more dewatering, and will employ possibly 10 times as many people as will an in situ operation. The reader is referred to statements on tracts C-b and U-b for more information on the effects of underground mining.

Tract No. U-b - It has been proposed that this tract be developed by underground mining using the room and pillar method with an inclined shaft or shafts.

Oil production at the rate of 50,000 barrels per day will require about the same amount of process water (5.5 mgd or 8.5 cfs) that was estimated for site U-a. The same general discussion of potential surface and subsurface supplies and disposal of waste water that was presented for tract U-a also applies to tract U-b.

Problems of tract U-2 of mine dewatering and disposal of dewatering water are similar to problems discussed for tract U-a. However, the size of the excavation for a room and pillar operation will be considerably larger than the excavation for the in-situ operation at tract U-a; therefore the volume of water will be larger (possibly several tens of cfs).

Large volumes of spent shale, and moderate volumes of overburden and crushed shale will be produced. These will present environmental problems of possible erosion and leaching similar to those discussed for tracts C-a and C-b. After one or two years of mining operation, it will be possible to dispose of some of the spent shale in the completed mining areas. However, not nearly enough volume will be available to handle the expanded shale, so surface disposal will continue through the life of the mining operation.

Subsidence caused by pillar collapse could affect drainage patterns in the region of the mining operation. However, this does not need to be a matter of great concern if mining rooms are backfilled with spent shale as soon as work in an area is completed.

Potential ground-water contamination from contact with the spent shale, or from slurry leachate is of concern, just as it is for tract C-b and for other underground mining sites. See the discussion of environmental impact for tract C-b for a more detailed explanation of this problem.

Potential sediment and chemical stream pollution from accidental spillage, pipeline construction, road construction, and plant construction, as well as possible stream cutting, must be considered at tract U-b, just as they were considered in appraisal of other sites. See the section on environmental effects at tracts C-b and U-b for a more complete discussion of these topics.

Increased water supply in communities near the tract will have to be provided to meet the needs of employees and their families. Approximately 600,000 gpd of potable water will be needed, and water-treatment facilities will be required to serve about 4,000 people. It is difficult to predict where these people will live, but it is estimated that 15 per cent of them may live on or near the tract.

Whereas the above discussion has considered only environmental effects of conventional mining, it is possible that in-situ processes may be used at Tract U-b. Environmental effects of in-situ retoring in the Uinta Basin are discussed in the appraisal of tract U-a, and the reader is referred there for additional information.

3.b.3 Water Resources (Wyoming)

Tracts No. W-a and No. W-b - These tracts most probably will be developed using a modified in-situ method. Shafts and tunnels will be excavated, but the details of the in-situ processing method to be used are not known.

Oil production at the two sites may reach a combined rate of 50,000 barrels per day and will require about 5.5 million gpd (8.5 cfs) of processing water. Small amounts of fresh water are available in the shallow aquifer, but it is doubtful if shallow wells on the tracts could supply the needs of the industry. Adequate supplies may be developed by wells tapping deeper aquifers, but few data are available from which to predict the amount and quality of water that might be found. Because streamflow is intermittent, pumping of ground water is not expected to have a significant determinable effect on streamflow. Possibilities for reservoir storage of surface water exist to meet the annual industry needs of about 6,200 acre-feet, but because of high evaporation losses and high construction costs little thought will be given to this possibility until after the ground-water resources are explored more completely. Adequate ground-water exploration will require considerably more data on aquifer characteristics and water quality, as well as construction of a predictive mathematical model.

Process waste discharges will be the only source of flow in small streams in the area for much of the year. These discharges probably will be permitted if the wastes can be treated to meet Wyoming water-quality standards, but it is expected that the discharged wastes could cause erosion of streambeds and banks. If the wastes cannot meet surface water standards they might be disposed of underground. Feasibility of subsurface disposal will depend upon locating a suitable deep aquifer. Present data are inadequate to even permit further speculation on this possibility but ground-water quality deterioration and an increased probability of seismic activity would be two environmental impacts that would have to be considered if the procedure was used.

It probably will be necessary to dewater mine excavation for the in situ operation, but no data are available for predicting how much water will have to be pumped. It also is not possible to predict the quality of the water to be produced by the dewatering, or the possibility of disturbing a fresh water-salt water interface, if one exists.

The in situ process eliminates most of the common problems of overburden storage and storage of spent shale. However, small amounts of material will be excavated, and these represent potential pollution problems caused by sediments being washed into streams.

Because details of the in situ process are not known, it is impossible to predict the effect of the retorting on the quality of ground water. Solvents or oil might escape into the aquifers if not contained. Spent shale left in place also is likely to leach organic and inorganic contaminants to ground water after the in situ processing is completed and dewatering is stopped.

Several possibilities exist for stream pollution from mining on the tracts. These include accidental spillage of oil from pipelines or tank failure, land erosion, and stream sedimentation from construction of pipelines, roads, and plant facilities, and possible waste discharge necessitated by the breakdown of waste treatment facilities.

Only about 100 people are expected to be employed on the site after initial construction. Most of these are expected to live in Rock Springs, but it is expected that they will put only modest increased loads on the community's water supply and waste disposal systems.

Although in situ processing is expected to be used, oil shales on tracts W-a and W-b might be developed by underground mining. Previous discussions of environmental impacts at tract C-b treat the subject of underground mining, and the reader is referred to that section.

SUMMARY OF WATER RESOURCE PROBLEMS - COLORADO

	C-a Open-Pit Mine	C-b Undergound Mining Surface Retort
urface Water: Source,Transport & Storage	No problems. Assume process can use dewatering water.	Probably not necessary. Shallow ground water or dewatering water may meet process needs.
round Water Supply Potential	No problem. Assume process can use dewatering water.	Good water available at about 600', but streamflow effect is a problem
ewatering: Amount, Quality, Disposal, Aquifer Effects	Large volume (15-50 cfs) TDS 2000 streamflow into pit	Large volume. Moderately salty and may get worse with pumping. Might be reinjected.
pent shale Disposal: Leaching & Erosion	May be 5 or more years worth to store. Method unsure. Control required.	Method unsure. Control required.
rocess Waste Water Disposal	Treat with Dewatering Water	Treat and dispose with dewatering water.
ccidental Spillage	G	G
rushed Shale Storage	Function of terrain & site. Control required	Function of terrain & site. Control required.
ipe Construction	G	G
oad Construction	Present roads need improvement 15 mi. Surfacing no problem. Grading is.	New road (with grading) will be needed for 5 miles.
urface Erosion Due to Plant Construction	G	G
isposal of Overburden	Big problem (off site).Control needed for erosion.May effect chemical quality of water.	Minimal problem. Treat same as spent shale.
ovement of Fresh Salt Boundary	Important w/large dewatering and permeability. Math model needed.	May be major problem because of location near center of Basin.Math model needed.
aste Left In-Situ	-	Backfill with spent shale may be problem, especially if saline-water slurry is used.
ubsidence Effect: On Drainage	-	Important if pillars fail.Backfilling could prevent subsidence.
ncreased Population:Water,Power,Waste	G	G
hannel Erosion from Increased Flow	Fairly large factors.Pit will store flood waters.	Major factor,if water is fit for surface disposal
quifer Contamination from In-Situ Process	-	-

G - Treat as a general topic for all sites.

3.c Wildlife

Habitat changes affecting fish and wildlife resources can be anticipated following initiation of oil shale processing operations throughout affected portions of the three-state area. Wildlife food and cover will be altered or temporarily eliminated on the anticipated 40,000 acres which will be involved at mine sites, excavations, spoil disposal areas, or through construction of roads, utility corridors and other support facilities. On a broader scope, the addition of an industrial complex, with accompanying personnel, machines and activities, will have a measurable adverse impact on wildlife populations and use patterns well beyond the immediate area of mining and processing operations. Dependent upon the ultimate mining method utilized at individual test-lease sites, the total human population in the oil shale region could increase by 47,000 people at the end of six years of prototype operations.

3.c.1 Wildlife - Colorado

(1) Test-Lease Tract C-a

A detailed description of the fish, wildlife, and related recreational values inherent in Tract C-a is presented in Section 2, Description of the Environment.

(a) Description of Operations

Under test lease oil shale development the construction, operations and servicing of plants on Tract C-a would result in both direct and indirect impacts upon

the normal behavior and activity patterns of wildlife within the 5,130.4 acre site. Additionally, an adverse impact on fish and wildlife resources will be experienced throughout off-site areas utilized for vehicular access, electrical power, gas and water transmission corridors, as well as waste disposal withdrawals.

The direct impact on wildlife habitat within **Tract C-a** through surface disturbance will be dependent upon the mining method selected by industry, since the site has potential for recovery by all three techniques. Under surface mining techniques overall mining operations will result in the eventual disturbance of the entire 5,130 acre tract, plus an additional 1,000 acre off-site waste disposal area situated in the Cathedral-Douglas Creek drainage. Through utilization of underground, room and pillar or In-Situ methods, total direct surface disturbance will be restricted to approximately 2,000 acres and 60 acres respectively.

Either of the mining processes will result in the need for electrical power, natural gas and water supplies, brought in through transmission corridors, as well as an improved road system to provide suitable access for needed equipment and personnel. Utility needs are expected to involve a three-mile extension

of electric power transmission lines from an existing source at Stake Springs Draw; a one-mile extension of natural gas pipeline from a 16" line located to the southeast; and construction of a 25-mile water transmission line from a site on the White River. Major improvement will be required on 16 miles of dirt access road extending from the mouth of Ryan Gulch (Piceance Creek Highway) to the construction site.

It is anticipated that oil production from test-lease operations will be marketed by pipeline transmission to a railhead site on the Colorado River, resulting in need for a cross country transmission line extending southward for an estimated distance of 50 miles.

(b) On-Site Impacts

Surface disturbance resulting from on-site mining and processing operations will result in the direct loss or reduction of wildlife food and cover through partial or complete removal of existing vegetation within the development tract. In addition to habitat loss through surface disturbance there can be expected to be certain areas avoided by most forms of wildlife because of disturbance factors related to industrial noise and high levels of human activity. As shown

by McKean and Bartmann (1971), the loss of surface vegetation or its use through mining disturbance on each section (640 acres) within areas of good deer habitat, will result in the potential reduction in carrying capacity for up to 50 deer.

Through the physical effects of mining operations, as well as the anticipated use of ground water for processing and development activities, it is anticipated there may be a general lowering of natural surface water features, including springs and seeps, historically utilized by local wildlife populations.

The exclusion of the test-lease tract and disposal sites from general public use will result in the loss of up to 6,000 acres on which sport hunting and general recreational opportunity may be denied for an indefinite period of time.

(c) Off-Site Impacts

Surface disturbance and the resulting loss of valuable habitat to wildlife will be experienced within selected waste disposal areas, as well as throughout the length of proposed highway, utility, and oil transmission corridors unless carefully designed. Such service facilities often have potential for adverse impacts to wildlife species.

A permanent loss of surface vegetation adjacent new highway structures can be anticipated along rights-of-ways averaging 60 ft. in width. This will result in the removal of approximately 8 acres of wildlife habitat per linear road mile.

An additional temporary loss of wildlife food and cover, equaling approximately 2½ surface acres per linear mile, will be experienced through the development of all utility (gas, water, and electric power) corridors, as well as needed oil marketing pipelines. These rights-of-ways, averaging 20 ft. in width, will be restored to former levels of productivity through application of available cultural techniques showing the greatest promise of success.

The construction of a surfaced highway system from the mouth of Ryan Gulch to the development site will result in heavy-use vehicular penetration of an additional 16 miles into a relatively remote and primitive portion of the Piceance Basin. Such increased travel volumes associated with proposed industrial development can greatly increase the incidence of hazardous vehicle-wildlife strikes.

Pipeline facilities and power transmission lines anticipated in the project plan contain certain structures and control features which, unless carefully

designed and maintained, affect the well-being of associated fish and wildlife resources.

It is recognized that overhead power transmission lines often present a hazard to certain bird species, particularly to raptors and eagles using such structures for perch sites.

The failure of a major pipeline system as required for the marketing of plant production could have a serious potential adverse impact on the surrounding environment. The extent of impacts from accidental oil losses, if they were to occur, would depend upon numerous factors, including volume of oil lost, leak location, weather conditions, quantity and quality of wildlife habitat affected, timing with respect to organism life history stages, and effectiveness of contingency plans. Most significant impacts would likely result to fish, aquatic organisms and water related birds and mammals.

The oil shale area in Colorado exhibits limited fishery potential. However, prototype operations on Tract C-a together with off-site utility transmission facilities, would have potential to cause off-site stream degradation with subsequent adverse effects on fish and other aquatic populations, if pollution control

provisions are not carefully designed or should fail in emergency situations.

A major off-site impact of test-lease development operations on wildlife resources will involve a significant disruption of deer migration patterns between seasonal range areas, not only within the immediate vicinity of the work area, but also affecting those general populations which will continue to follow migration routes crossing highways carrying increased traffic volumes.

The maximum rate of development of the prototype oil shale program in Colorado over a six-year period could result in the influx of an estimated 25,000 persons, of which approximately 3,000 may be directly involved in mining, processing and construction activities at lease sites. Facilitated access resulting in increased habitation and activity will bring many of these individuals in greater contact with fish and wildlife resources. As a result, the overall populations of some of the Basin's more intolerant species, such as mountain lion, bear, and elk could be expected to decrease, whereas, the more popular game species, including mule deer, blue grouse, sage grouse, chukar partridge, rabbits, doves and waterfowl would be expected to receive proportionately increased hunting pressure.

Of particular concern is the future welfare of those previously identified endangered or threatened species, since the net impact of industrial operations and increased human activities could easily contribute toward a further disruption of the delicate ecological balance within which these species continue to survive.

Although the anticipated increase in human populations and their associated activities will present a number of significant wildlife resource problems, the overall recreational use-potential of the oil shale region will undoubtedly be increased through improvement in access from roads and trails which will be constructed to facilitate the mining operations.

(2) Test-Lease Tract C-b

A detailed description of the fish, wildlife, and related recreational values inherent in Tract C-b is presented in Section 2, Description of the Environment.

(a) Description of Operations

Test-lease development will result in both direct and indirect impacts upon the normal behavior and activity patterns of wildlife within the proposed 5,114 acre site, as well as throughout off-site areas utilized for vehicular access, electrical power, gas, and water transmission corridors.

The direct impact on wildlife habitat within the boundaries of Tract C -b, through surface disturbance, will be dependent upon the mining method employed by the industrial contractor. With underground, room and pillar methods, for which the tract is primarily suited, major surface disturbance will be confined to an area totalling approximately 2,000 acres. If industry elects to utilize the In-Situ technique, such disturbance would be confined to an area of approximately 60 acres. There will be no requirements for waste disposal or storage outside the identified boundaries of the tract.

In the conduct of test-lease mining and processing operations there will be need for electrical power, natural gas and water supplies, brought in through transmission corridors, as well as development of a short access road connecting the development site with the surfaced highway on Piceance Creek. Utility needs are expected to involve a one-mile extension of electric power transmission lines from an existing source on Piceance Creek; a six-mile natural gas pipeline from an existing distribution station on the Little Hills Triangle; and construction of a 30-mile long cross-country water transmission line from a site on the White River. Improved road development

will be limited to a two-mile spur off Piceance Creek highway.

It is anticipated that oil production will be carried by oil transmission pipeline to the Rifle, Colorado, railhead, an approximate distance of 30 miles.

(b) On-Site Impacts

The impact of test lease operations on wildlife resources at Tract C-b is expected to closely parallel those described for Tract C-a. A major exception, however, relates to the reduced danger of total surface disturbance at Tract C-b, since open-pit mining techniques are not envisioned in the operational plan.

(c) Off-Site Impacts

Test-lease development at Tract C-b has the potential for creating off-site impacts on fish and wildlife resources similar to those described for Tract C-a. Although increased traffic volumes on major access highways will subject more wildlife to road-kill hazards, and present an added obstacle to certain seasonal movements, the overall impact of highway access into Tract C-b on wildlife resources will be greatly reduced from that described at Tract C-a. There will not be a

major penetration by improved highway into remote wildlife habitats, since Tract C-b lies immediately adjacent an existing surfaced roadway.

3.c.2 Wildlife - Utah

(1) Test Lease Tracts U-a and U-b
(Adjacent tracts having common fish and wildlife impact potentials.)

A detailed description of the fish, wildlife and related recreational values inherent in tracts U-a and U-b is presented in Section 2, Description of the Environment.

Under test-lease oil shale development, the construction, operation and servicing of prototype plants on Tracts U-a and U-b, together with the marketing of recovery products, will result in both direct and indirect impacts on the normal behavior and activity patterns of wildlife, as well as on public recreational use within the 5,120 acre tracts. Additional impacts will be observed throughout off-site areas utilized for vehicular access routes or electrical power, gas, oil and water transmission corridors.

The direct impact on wildlife habitat within the boundaries of the two adjacent tracts will be dependent upon the mining method employed by the industrial contractor. With the underground (room and pillar) method, for which the tracts are best suited, major disturbance will be confined to an area totalling approximately 2,000 acres on each site. Development methods by way of surface (open-

pit) techniques, involving eventual disturbance of the total acreage, or the In-Situ process, utilizing about 60 acres per tract, are considered unlikely.

In the conduct of test lease mining and processing operations, there will be need for electrical power, natural gas and water supplies, brought in through transmission corridors, as well as the development of an improved access road connecting the development sites with the surfaced highway currently terminating at Bonanza, Utah. In addition, a lengthy pipeline will be required for the marketing of various production products.

Utility needs for the two tracts are expected to involve a 10-mile extension of electric power transmission line from an existing source on White River; a 15-mile natural gas pipeline from an existing facility at Bonanza; and construction of a 10-mile water transmission line from a proposed diversion site on the White River. Improved road construction will consist of a surfaced highway extension from the community of Bonanza, located 15 miles to the north.

It is anticipated that marketable oil production will be carried by transmission pipeline to a railhead at Mack, Colorado, a cross-country distance of approximately 50 miles.

(a) On-Site Impacts to Fish and Wildlife Resources

The overall impact of test-lease operations on wildlife resources at Utah Tracts U-a and U-b are expected

to closely parallel those described for Colorado Tract C-a. An exception, however, relates to the reduced potential for surface disturbance within the tract boundaries, since open-pit techniques are not envisioned in the operation plan for Utah sites.

(b) Off-Site Impacts to Fish and Wildlife Resources

Test-lease development of the two designated tracts in Utah has the overall potential for creating off-site impacts similar to those described for Colorado Tract C-a. The proposed extension of a surfaced, heavy-use highway system into a rather remote range area will subject resident wildlife to added road-kill hazards, and human disturbance, however, seasonal deer migrations are of lesser significance than those outlined for the Colorado Tract.

The danger of downstream contamination of major waterways, and subsequent degradation of fish and aquatic habitats, is of considerable significance, since the Utah test-lease tract boundaries lie adjacent to, or within a short distance of, the White River channel.

The anticipated rate of development of the prototype oil shale program in Utah over a six-year period could result in the influx of an estimated 6,000 persons, of which approximately 1,000 may be directly involved

with mining, processing and construction activities at test-lease sites or in development and maintenance of associated facilities. Improved area access will bring a greater portion of the total human population in closer contact with surrounding fish and wildlife resources.

3.C.3 Wildlife (Wyoming)

(1) Test lease tracts W-a and W-b
(Adjacent tracts having common fish and wildlife impact potentials)

A detailed description of the fish, wildlife and related recreational values inherent in tracts W-a and W-b is presented in Section 2, Description of the Environment.

Under test-lease oil shale development, the construction operation and servicing of prototype plants on W-a and W-b, together with activities related to the marketing of recovery products, will result in both direct and indirect impacts on the normal behavior and activity patterns of wildlife, as well as on public recreational use within the two 5,120 acre tracts. Additional adverse impacts will be experienced throughout all off-site areas designated for use as vehicular access routes or electrical power, gas, oil, and water transmission corridors.

Although it is unlikely that surface open-pit mining processes will be employed on Wyoming tracts, the two sites appear to have potential for development through the

underground (room and pillar) or In-Situ techniques. Major surface disturbance anticipated through use of the underground method will equal about 200 acres per tract, whereas, utilization of the In-Situ technique will limit such impact to an area approximating 60 acres per site.

A number of service facilities will be required in support of prototype oil shale mining and processing activities, including electrical power, natural gas, and water supplies brought in through transmission corridors; a lengthy cross-country oil products pipeline for marketing purposes; as well as an improved access system, linking the development sites with surfaced highways.

In servicing the Wyoming tracts, utility needs will involve construction of a power transmission line from major electric power sources at the Jim Bridger plant (Pacific Power and Light), 40 miles to the north, or from Rock Springs, Wyoming, approximately 40 miles to the northwest. Natural gas may be secured at the Powder Wash or Hiawatha oil fields located in Colorado, approximately 30 miles to the south, or from Rock Springs, Wyoming. Either source will involve construction of a lengthy, cross-country pipeline system.

Water requirements at the oil shale development sites will be met through pipeline diversion, originating at the

Flaming Gorge Reservoir, approximately 50 miles to the west. Improved vehicular access will involve development of 25 miles of new road, connecting the test-lease sites with surfaced highways Interstate 80 to the north or Wyoming No. 430 to the west. Marketable oil products will be transported to a railhead site on the Union Pacific line, located approximately 25 miles to the north.

(a) On-Site Impacts to Fish and Wildlife Resources

The overall on-site impacts of test-lease operations on wildlife resources at Wyoming tracts W-a and W-b are anticipated to be of the same type and importance as those outlined for Colorado Tract C-a. There is expected to be some difference in the degree of impact, however, since Wyoming tracts are not likely to be subject to the total disturbance associated with open-pit mining, and annual sport-hunting or recreational use demands have not been as great as those experienced recently on the Colorado C-a site.

(b) Off-Site Impacts to Fish and Wildlife Resources

Industrial development associated with prototype test-lease oil shale operations will have a considerable impact on wildlife habitats in an area well beyond the immediate boundaries of identified lease sites on Kinney Rim. The general region surrounding proposed development

tracts is still quite remote; remaining as a relatively primitive area, currently little affected by human influences.

The adverse off-site impacts to wildlife resources, described in detail for Colorado Tract C-a, will basically apply to a broad habitat area in the vicinity of Wyoming operations. The anticipated radius of influence is quite large, in that all major service facilities, including electrical power, oil, gas and water transmission corridors, as well as improved highway systems, will extend for considerable distances. All such features, unless carefully designed and maintained, have the potential to adversely affect the well-being of representative fish and wildlife resources.

The anticipated rate of prototype oil shale development in Wyoming over a six-year period could result in the influx of an estimated 2,500 persons, of which approximately 500 may be directly involved in overall processing operations. Improved area access associated with the test-lease program will bring a greater portion of the total human population in closer contact with surrounding fish and wildlife resources.

3.d.1 Soils and Vegetation (Colorado)

Tract C-a - This tract is considered to have potential for three types of mining; open pit, underground, and in-situ. In order to evaluate the environmental surface impacts, each potential mining method must be considered separately since each method requires a different type and amount of surface disturbance. Surface disturbance areas are based on projections made by the U.S. Bureau of Mines.

(a) Open Pit Mining

If the lessee elects to use this type of mining, there will be a severe impact on the entire tract surface and possibly on a significant off-site acreage. It is estimated that 150 acres will be converted to processing plant facilities. The remaining 4,970 acres will be subjected to open pit mining operations. It will be necessary to remove about 5 billion cubic yards of overburden to reach the oil shale at depths of approximately 100 to over 600 feet. Spent shale, the by-product of processing, would be produced at a rate of approximately 130,000 tons per day or about 6 billion cubic yards over the life of the mining operation. To dispose of the overburden and spent shale off site would require approximately 12,500 acres. In place of the present environment on the 5,120 acre tract an excavation some 800 feet in depth would be created. This would appear to be unacceptable from an environmental viewpoint.

To meet the environmental objectives of the oil shale leasing program, a plan for replacing both overburden and spent shale into the mined pit would be developed. This would require an initial off site deposition of 265 million cubic yards of overburden to allow mining. As mining operations expanded, the mined out areas would be backfilled with overburden and spent shale. As filling operations progressed, the land surface would be shaped to conform to the original landscape and revegetated. Land restoration and revegetation plans would utilize the latest techniques. The spent shale deposition would be planned to assure successful revegetation. Trials are now underway by the Soil Conservation Service, Colorado State University, and Atlantic Richfield Oil Company to determine the feasibility of establishing and maintaining vegetation on spent shale and mixtures of spent shale and soil. The results of these trials will influence the methods acceptable for revegetation.

Approximately 35 per cent of the tract area contains top soil materials suitable for stock piling and redistribution to the surface of fill areas, should this be necessary to successfully reestablish desirable vegetation. Plant materials adapted to the site conditions are available or could be produced by the time needed. These include native and adapted introduced grasses and desirable native shrubs.

It is estimated that no more than half the area to be mined would be disturbed before restoration and revegetation operations were initiated. By completion of mining operations, the excavated area would be completely filled, shaped, and revegetated.

In addition to the mined area, surface impacts would be created at the off-site disposal area, along roadways, and in utility and pipeline corridors. These areas would be restored and revegetated as soon as practical after disturbance.

The 150 acres used for plant facilities would eliminate this area from other uses during the life of the project. Critical areas created during construction would be revegetated to prevent erosion and improve aesthetics.

(b) Undergound Mining and Surface Processing

This type of mining would entail extraction of oil shale from underground and delivery to the surface through vertical shafts. The greatest impact on the surface environment resulting from this type of operation would be from the deposition of spent shale material following extraction of the carogens. A 50,000 barrel-per-day operation would produce about 60,000 tons per day of spent shale material or about 3 billion cubic yards over the life of the project.

Spent shale material could be deposited in canyon areas off site, on top of the landscape on site, or by a combination of surface deposition and refilling of underground mine cavities. The combination method would substantially reduce the surface impact and improve the stability of the mine structure to reduce surface subsidence.

This method would require surface deposition during the first three years of operation. After that period, 60 per cent of the spent shale produced would be returned to the mined area underground.

To deposit all spent shale material on top of the land would require from 6,000 to 7,500 acres, assuming piles would average 250 feet in height. The method involving refilling the mine cavities would require about 2,500 to 3,000 acres of surface deposition.

The method used to reshape and revegetate the spent shale piles will depend on trials now underway. If topsoil is needed to mix with the shale or to top dress the shale for successful revegetation, it could be stockpiled from the 35 per cent of the tract area having suitable soils and applied as needed. Revegetation could be done progressively as spent shale piles develop.

This type of mining would also require surface disturbances related to road construction, processing plant construction, and utility and pipeline corridors. These areas would be revegetated as soon as practical to prevent erosion.

It is estimated that 100 acres will be converted to processing plant facilities. This land would be excluded from other uses during the life of the project operation.

(c) In-Situ Recovery

This type of mining involves extracting the oil product from the shale in place by heating it undergound. This type of operation would have a minimal environmental effect on the land surface. Approximately 45 acres would be required for plant facilities. There would be no spent shale material produced above ground. Surface environmental impacts would be confined to the plant facilities area, roadways, and utility and pipeline corridors. Critical areas related to these disturbances would be revegetated as soon as practical.

Tract C-b - Because of the depth of overburden above the oil shale deposits, it is not considered likely that open pit mining will be proposed on this tract.

Surface disturbances created by underground or in-situ mining would be essentially the same as described for Tract C-a.

The tract surface is similar to that of Tract C-a. It is located in essentially the same annual precipitation zone, but contains a higher percentage of sites lacking good topsoil. Approximately 25 per cent of the surface area contains topsoil suitable for mixing or top dressing spent shale piles. Plant species adapted to the tract sites are the same as for Tract C-a.

3.d.2 Soils and Vegetation (Utah)

Tract U-a and U-b - These tracts are considered to have potential for either undergound mining or in-situ mining. Surface disturbances would be similar to those described in Tract C-a.

These tracts are in a precipitation zone of 8-10 inches annually. Revegetation and land restoration would be accomplished as described in Tract C-a.

Revegetation would be accomplished with available adapted species.

3.d.3 Soils and Vegetation (Wyoming)

Tracts W-a and W-b - These tracts are considered to have potential for in-situ mining only. Surface disturbances would be similar to those described under Tract C-a -- in-situ mining.

The tracts receive about 10-12 inches of precipitation annually and contain soils suitable for revegetation. Disturbed areas would be revegetated with adapted species as soon after disturbance as practical.

3.e. Air Quality and Noise Impacts

It is difficult to rate sites within a particular state from an air quality standpoint, since all the sites in a particular state are relatively close together and are in fairly isolated areas. Night-time temperature inversions might be relative to the sites selected within a state, as indicated in the C.S.U. environmental inventory for the Piceance Basin:

> "Night-time air temperatures are largely dependent upon physiography with air drainage (valley winds) the dominant elements. A night-time inversion, with light drainage winds, is typical throughout the Piceance Basin. Under these conditions the typical night-time surface flow pattern is down the creek drainages to the north and northeast, then turning westward down the White River valley. The vertical temperature structure is usually neutral to moderately unstable during afternoon with a temperature inversion forming shortly after sundown. The trapping layer under this inversion is probably less than 1500 feet thick. A short-term temperature record on Cathedral Bluffs indicated that the inversion height is usually below 8500 msl. In Parachute Creek near Grand Valley, Colorado, the inversion height is between 7200' and 8500' msl. Inversion

> heights, it should be noted, are not a function of altitude above mean sea level but rather above the ground surface.
>
> During mid-winter, the inversion normally breaks at least by early afternoon. Under certain synoptic conditions, however, temperature inversion conditions may persist for several days at a time. During the summer and fall months, the inversions will normally break by mid-morning.
>
> The tendency for air drainage and temperature inversion conditions indicates a potential air pollution problem. There are, at present, no major sources of pollution within the inventory area. If gaseous or particulate matter are to be released into the atmosphere as part of the oil shale processing, it would be necessary to assure that the stack height extend above the local area inversion level and that the plume be forced vertically to higher levels. The plume direction would then probably be in the general direction of the upper level wind, i.e., to the northeast."

In Utah the difference in elevation among the sites is only 800 feet and therefore is probably not significant. If it is assumed that the prevailing winds in the Uinta Basin are similar

to those in the Piceance Creek Basin, i.e., from the southwest, then sites 1, 2, 4, and 5 would probably affect the air quality in the Rangeley, Colorado area more than site 3. Offsetting this, however, is the fact that site 3 is at the lowest elevation (5,000') of all the sites.

The situation in Wyoming is different with regard to meteorological dispersion of air pollutants from the other two state areas. Predominantly, westerly winds sweeping across the Kinney rim sites would be expected to fan the stack plumes out in the prevailing wind direction, although meteorological data is needed to adequately describe mixing depths and the degree of dispersion. Inversion conditions would be expected to present less of a problem here.

Initially, construction noises from diesel trucks, compressors, mixers, drills, etc., would occur that might undesirably affect wildlife in the area. Oil shale region animal species sensitive to noise in decreasing order of effect are: mountain lion, bear, elk, mule, deer, antelope, sage grouse, blue grouse, and migratory birds. Small mammals, furbearers, and non-game birds would not be significantly affected, although their numbers in the vicinity of oil shale operations would decrease in proportion to disturbance and habitat lost.

Once the processes for oil shale are developed, a variety of noise problems could occur. In the in-situ extractive modes, underground blasting, compressors, pumps, etc., would provide noise sources. Conventional strip mining would require power shovels, earthmovers, conveyors, grinders, etc., that would generate considerable noise. Similar problems would occur with underground mining techniques. Retorting and upgrading processes would emit noises characteristic of refinery operations, although the level of noise would depend on the specifics of the operation.

A general increase in the noise level of the entire settled area would be expected as workers and families move into the area and create noises characteristic of the urban environment.

3.f.1 Recreation and Asthetics (Colorado)

Tract C-a

On Site Impact - The early period of development, the first three to five years, will probably have little impact on the recreation on this site. The area adjacent to the development work will not be available to hunters but will be limited in scope. As development progresses it is felt that approximately 50% of the existing types of recreation on the site will be lost. The deer hunting will be lost because of the activity at the mine as well as a safety buffer required for the mine workers. The activity will make adjacent parts of the area unsuitable for camping as well.

The development of two large scale mines will result in a new recreation source for the general public. Such things as tours, a visitor center and public displays will attract sightseers. Due to the remoteness of the area this sightseeing will likely not reach the proportions it would elsewhere but it is entirely probable that it will exceed the number of visitor days per year being spent on other activities on the site.

Off-Site Impact - Deer hunters displaced from this site will likely concentrate elsewhere in the Piceance Basin and the adjacent regions. These hunters, as well as those related to normal population growth, will increase hunter density and result in lowering of the existing quality of the hunting experience.

A percentage of the miners and their families will seek a portion of their recreation in the adjacent region. This will include sightseeing, both on and off road, camping, fishing, etc. This will result in a moderate increased use on secondary roads; thereby increasing maintenance needs on them, increased litter on undeveloped campsites and increased fishing pressure in rivers and streams. It is anticipated that additional use will be made of the excellent recreation facilities, both private and public, in and adjacent to the White River National Forest. These facilities are off major highways and are presently not fully utilized. These recreational areas are in reasonable proximity to the oil shale development area.

Aesthetics (Open Pit Type Mine) - This area is currently remote and used only by ranching, oil and gas personnel and hunters. There is no air pollution and the only noise pollution is directly related to scattered drilling rigs and exploring for oil and natural gas and coring the oil shale. The natural landscape is marred by roads and trails, cleared fence lines and gas pipelines on cleared rights-of-way.

The only values for recreation, other than deer hunting, are the open, unlimited vistas and the solitude.

With impact being greatest at the point of development, and diminishing by varying degrees as you move further from this point, aesthetic values to be impacted are:

(1) Natural quiet will be lost at the mine and plant site. The noise tied to these activities will be noticeable for a limited distance from the point of activity including access routes. Noise from motors, heavy equipment, etc., related to the operations will be an additional impact in the Douglas Creek Drainage adjacent to the active disposal site. The development of an open pit operation would provide a scenic vista which increase tourist traffic.

(2) The clean air may be degraded occasionally by dust from waste piles or vehicles. Impact from the mine and retort may not be significant during summer months since normal corrective lifting will put particles into prevailing winds aloft. Inversions during the winter months may trap emissions in the basin and result in an accumulation of contaminants. Dust from the spent shale disposal area on Douglas Creek under nighttime inversions common in the drainage during the summer could result in increased air pollution if not properly controlled.

(3) Visual impact from disposal of spent shale and overburden storage will be notable until restoration activities are completed. The plant will be visible from ridgetops miles away. Degree of impact will be related to the distance the viewer is from the development. Spent shale disposal in the Douglas Creek Drainage will alter the view of the Cathedral Bluffs from the Douglas Creek road and also the view of the Douglas Creek drainage from the top of the Bluffs.

Impact to the aesthetic values of the area due to utility rights-of-way such as pipelines, powerlines and roads will be:

(1) Visual impact inflicted by introducing a symmetric form, as cleared areas, onto an asymmetric landscape.

(2) Noise pollution along roads from vehicles.

(3) Visual impact will be limited to the vicinity of developed site although the plant may be visible from ridgetops several miles.

3.f.1 Recreation and Aesthetics (Colorado)

Tract C-b

On Site Impact - The early period of development, the first three to five years, will probably have little impact on the recreation on this site. The area adjacent to the development work will not be available to hunters but will be limited in scope. As development progresses it is felt that approximately 30% of the existing types of recreation on the site will be lost. The deer hunting will be inhibited because of the activity at the mine as well as a safety buffer required for the mine operations.

The development of a large scale mine will result in a new recreation source for the general public. Such things as tours, a visitor center and public displays will attract sightseers.

Off-Site Impact - Deer hunters displaced from this site will likely camp and hunt elsewhere in the Piceance Basin and adjacent regions. These hunters, as well as those related to normal population growth will increase hunter density and result in a lowering of the existing quality of the hunting experience.

Aesthetics (Room and Pillar and In-Situ Type Mines)- This area is currently remote and used only by ranching, oil and gas personnel and hunters. Except for naturally occuring dust storms there is no air pollution and the only noise pollution is directly related to scattered drilling rigs and exploring for oil and natural gas. The natural landscape is marred by roads and trails, cleared fencelines and gas pipelines on cleared rights-of-way.

The only values for recreation, other than deer hunting, are the open, unlimited vistas and the solitude.

With impact being greatest at the point of development, and diminishing by varying degrees as you move further from this point, aesthetic values to be impacted are:

(1) Natural quiet will be lost in the vicinity of the mine and plant site. The noise tied to these activities will be noticeable for a limited distance from the point of activity.

(2) The clean air may be degraded by dust from waste piles and dust from vehicles. Impact will not be significant during summer months due to normal corrective action lifting particles into the prevailing winds aloft. Inversions in the winter months may tend to trap emmissions in the basin and result in an accumulation of contaminants.

Impact to the aesthetic values of the area due to utility right-of-way such as piplines, powerlines and roads will be:

(1) Visual impact inflicted by introducing a symmetric form, as cleared areas, onto an asymmetric landscape.

3.f.2 Recreation and Aesthetics Impact (Utah) - Tracts U-a and U-b

Recreation - The oil shale project will increase the amount of outdoor recreation visitor use both on and around the project areas. It is likely that the tourist will use surrounding areas for sightseeing, picnicking, rockhounding, hunting, and floating and fishing on the White River.

Aesthetics -

(1) Visual - The underground mining operation will have a limited impact upon the aesthetics of the area. The plant area will be changed from its present state to a semi-industrial environment. It is estimated that the plant site would require a 100 acre tract. An additional 25 acres per year would be modified by the creation of spent shale piles. In addition, there will be pipelines, powerlines, roads and other service facilities.

Visual effects of in-situ recovery are more closely analogous to the petroleum industry techniques for thermal recovery of heavy crude oil. It is anticipated that less than 5 per cent of the land surface will be affected at any one time. This aesthetic deterioration can be rehabilitated by removing all man-made equipment and debris, smoothing over disturbed areas, and revegetation of each area.

(2) Sound - There will be sound pollution caused by mining, crushing and retorting. There will be noise caused by the operation of heavy equipment.

(3) Odor - There will likely be minor petroleum odors from the retorted hydrocarbon liquids and gasses.

3.f.3 Recreation and Aesthetics Impact (Wyoming) - Tracts W-a and W-b

Except as this proposed oil shale leasing program affects the visibility and esthetics of the area as described under Air Quality it is not expected to materially affect the value of the area for recreation purposes since it is at least 40 miles from a major state or national highway.

The impact on aesthetics would be limited provided that waste disposal would not be employed whereby this type of material would not impair the scenic view from the Kinney Rim. The wide open space aspect could be impacted if industrialized type of installations were constructed below the Rim or on the plain of Alkali Creek.

3.g.1 Occupancy and Land Use Impact (Colorado)

Tract C-a

On-Site Impacts - Impact on existing extensive land uses are covered elsewhere. The major impact is in changing from range and recreational uses to industrial uses. Development of the open pit will result in the loss of practically all present uses for the life of the operation.

Off-Site Impacts - The proposed spent shale disposal area west of Cathedral Bluffs will convert this area from an area grazed by livestock and wildlife to an industrial area with heavy equipment, pumps, slurry ponds, etc.

Utility corridors will undergo a change in vegetation but will generally be available for existing land uses.

Additional acreage will be required for new roads and widening existing roads.

Off-site urban development will change land uses wherever it occurs. Uses will change in areas adjacent to existing townsites if they expand.

Transmission line or power failure would pose a serious hazard in the right-of-way area. Records indicate the numer of wild fires being caused from broken powerlines is very small; therefore, the threat from fire is not considered significant. The possibility of animals coming in contact with a broken line is also considered to be very remote. The primary possibility of human contact would occur where the lines cross the public roads.

Tract C-b

On-Site Impacts - Impacts on existing extensive land uses are covered elsewhere. The major impact is in changing from ranching and recreational uses to industrial uses. These types of mines disturb a relatively small area and it is felt that impacts will not be significant.

Off-Site Impacts - Acreage will be required for new roads and for upgrading existing roads. Other utility corridors will experience a change in vegetation but will generally be available for existing extensive type land uses.

3.g.2 Occupancy and Land Use Impacts (Utah)
Tracts U-a and U-b

Land use patterns change from a ranching-wildlife use to a principal use for the development and production of petroleum base products from the indigenous oil shale resource.

3.g.3 Occupancy and Land Use Impacts (Wyoming)
Tracts W-a and W-b

Principally the land use will change from range uses to a principal purpose use of mining; a small loss is expected of available animal units months(AUM's) for grazing purposes for waste disposal. Rehabilitation of the waste disposal area will allow for sequential use of the land for grazing, however. A small loss of land for grazing and wildlife habitat will be encountered for the mine and mill area and the 40 acres necessary for a tank farm. To a smaller degree a loss of use of land will be felt for roads, power lines and pipelines and their satelite installations.

Natural wildlife activity will be affected and altered slightly by use of the land for mining and milling. The land is not critical for wildlife but animals may adjust their pattern because of human activity.

3.h. Urban and Socio-Economic Impacts

General

The leasing of the six tracts is expected to result in significant changes in the existing social and economic structures of the regions involved. In the case of Tracts C-a and C-b in Colorado the greatest impacts will occur in Rio Blanco and Garfield Counties (Rangely, Meeker, Rifle, Glenwood Springs, etc.) and to a lesser extent in Mesa County (Grand Junction).

The Utah leases, Tracts U-a and U-b, are expected to effect the greatest change in the immediately adjacent community of Rangely, Colorado, across the State line in Rio Blanco County, with lesser but noticeable influence on nearby Vernal, Utah, and Uintah County. In the case of Wyoming Tracts W-a and W-b the major close community to be effected will be Rock Springs, in Sweetwater County.

In the case of each of these communities and their associated county areas the inevitable transition, as development of the leases proceeds, will be from a more rurally oriented society to one of greater urbanization and industrialization. It is felt that the rate of growth can be sufficiently stable in each area that an attractive blending of present and anticipated cultural patterns will emerge. In the long-term the broadened Federal, State, and local tax base will make possible improved community services, and the increased income in each sub-region will result in increased economic opportunities at all levels.

An inevitable disruptive impact for all sub-regions will be the lag between increased demand for community services (schools, hospitals, municipal services, roads, etc.) and the ability of the counties and municipalities to finance the expansions required. But such a lag will also be felt in the private sector (housing, retail stores, physicians, service stations and garages, etc.). This will be due to the reluctance of private businessmen to respond to new demands for goods and services which initially are primarily the result of increased (but temporary) construction employment. In the long-term (six plus years after lease awards) these lags will tend to disappear, as production levels stabilize, permanent operating employment replaces constructtion employment, and the newly expanded communities begin to mature.

The "support" employment (defined as accompanying non-oil shale industry employment) generated by the leasing program can be expected to vary from a ratio of somewhat less than one support worker per one shale worker in the initial six years, to one to one and higher (1.4 to 1) as full-scale production at a total of the order of 350,000 bbl/da for the six sites is attained.

3.h.1 Colorado

Tracts C-a and C-b

The Colorado sites, C-a and C-b, are both located in southern Rio Blanco County. Access will probably be primarily from Meeker and from Rifle. It is expected that new population will be concentrated heavily in the Meeker and Rifle urban centers, and

also spread along the Colorado River valley communities eastward to Glenwood Springs and westward as far, perhaps, as Grand Junction. In the first three years of the leasing program (1973-6) some 400 workers in Colorado will be directly involved in the field investigations and design phases of the shale industry, and another 300 in support services. Total shale-industry associated population (including dependents) might be expected to be approximately 1,900 people, of which perhaps only one-half represent people new to the region.

The major Colorado regional impact will occur in the third to sixth year of the leasing program (1976-79), as construction activity begins, then peaks and declines, and is replaced by full-scale operation. (For illustrative purposes only, in order to depict typical socio-economic impacts, site C-a is assumed to be an open-pit operation of 100,000 bbl/da at full scale; and site C-b an underground mine operation of 50,000 bbl/da full-scale capacity. All 150,000 bbl/da of Colorado production would be processed in surface retorts).

Shale-based employment itself should reach 3,400 workers during the peak of construction, and decline to a steady state of 2,400 workers as full-scale production is attained. Accompanying "supporting personnel" requirements could total as much as an additional 3,300 workers at peak, and remain at this level. The total shale-industry associated population including dependents would increase in Colorado to 21,000 at peak, and then

decline to about 15,000 as full-scale production is reached. Most of these 15,000 would be permanent new additions to the present population of the region (19,400 in Rio Blanco and Garfield Counties, plus an additional 52,600 in Mesa County).

As mentioned previously in the general discussion this population increase will have a noticeable impact on the new community services required. A detailed analysis is beyond the scope of this study, but typical impacts will include the need for school facilities for at least 5,200 new elementary and secondary pupils, and the expansion of hospital facilities for the region by an additional 60 beds. At steady state, full-scale operation, however, local, state, and Federal tax revenues should be increased by a total of some $32 million annually.

3.h.2 Utah

Tracts U-a and U-b

The two Utah sites, U-a and U-b are located in Uintah County. They can be reached either from Rangely, Colorado, in nearby Rio Blanco County, Colorado, or from Vernal, Utah, which is some 60 miles away. It is probable that new population generated by development of these Utah tracts will be distributed (perhaps equally) between these two principal communities. The Utah sites development can thus be expected to superimpose further growth pressures on Rio Blanco County, Colorado, above those previously described for the Colorado sites, as well as producing expansion in the Vernal, Utah, region.

The pattern for total population growth will be similar to that for the Colorado sites, if it is assumed that underground mining and surface retorting would be the technologies involved. Regional population associated with shale development will total some 2,000 people during the initial design and field investigation phases (1973-6), of which perhaps 60% would be new people.

During the major growth period, 1976-79, from construction through to commercial operation at a total steady-state output of 100,000 barrels per day, total population, including the associated "support" population, will increase to 21,000 at the peak of construction, and then decline to 15,000 "permanent" new regional inhabitants in 1979. The new people, as previously mentioned, might be expected to be divided equally between the Vernal and Rangely communities.

The present population of Vernal, Utah, is approximately 4,000, and that of Rangely, Colorado, about 1,500. It is therefore obvious that noticeable disruptions in present socio-cultural patterns will occur in these communities, as industrialization occurs and the above population influxes are superimposed upon present life styles. Comprehensive land use plans and zoning ordinances will be needed to "promulgate" orderly growth. Financial assistance programs will be needed to bridge the lag between demand for new community and municipal services, and the tax revenues which can underwrite them. It is probable

that it is this Vernal-Rangely region on which the prototype oil leasing program will have the greatest overall impact.

3.h.3 Wyoming

Tracts W-a and W-b

Wyoming sites W-a and W-b are located in Sweetwater County, some 50 miles from Rock Springs, Wyoming, the nearest substantial community. Because of the nature and richness of the oil shale on these tracts, it is suggested that both sites might well be developed by in-situ processes.

The technology for in-situ processing is not as well advanced as for above-ground retorting, and indeed will be further developed as field operations are expanded. As a result the Wyoming sites will be brought into production over a longer time span than those in Colorado and Utah. In addition, if in-situ processing is successful, its total manpower requirements per unit of production will be considerably less than for mining plus surface retorting. As a result of both of these facts the socio-economic impact of shale development on the Wyoming tracts is expected to be less than on the other four sites.

It is estimated that workers directly involved with oil shale operations may reach a maximum of 300 to 400 people. "Supporting" personnel may double these figures. The total regional population associated with the oil shale industry may thus reach 1,000 people in the late 1970's as developments on the tracts mature.

that it is this Vernal-Roosevelt region on which the prototype oil leasing program will have the greatest overall impact.

3.4.3 Wyoming

Tracts W-a and W-b

Wyoming sites W-a and W-b are located in Sweetwater County, some 50 miles from Rock Springs, Wyoming, the nearest residential community. Because of the nature and richness of the oil shale on these tracts, it is suggested that these sites might well be developed by in-situ processes.

The technology for in-situ processing is not as well advanced as for above-ground retorting, and hence will be further developed as field experiments are expanded. This results the Wyoming sites will be brought into production over a longer time span than those in Colorado and Utah. In addition, if in-situ processing is successful, the total manpower requirements per unit of production will be considerably less than for mining plus surface retorting. As a result of both of these facts, the socio-economic impact of shale development on the Wyoming tracts is expected to be less than on the other four sites.

It is estimated that the number directly involved with oil shale operations may reach a maximum of 500 to 600 people. "Supporting" personnel are about three times this. The total regional population associated with the oil shale industry may thus reach [illegible] people if the full [illegible] is developed on the tracts.

Even such a population increase, however, could produce uncomfortable dislocations in the Rock Springs, Wyoming, area. Activities presently associated with the Pacific Power & Light-Bridger plant will continue to produce housing shortages, crowded schools, overloaded water and sewage plants, insufficient medical facilities, etc., in the region until at least 1976. The projected shale population increase will be superimposed upon these already strained conditions.

3.i.1 Archeology Impact (Colorado)

Tracts C-a and C-b

There are two basic impacts on archeological and paleontological resources; first, any type of land disturbing operations from roads to open pit mining could destroy the values; secondly, the increase in use and accessibility of the area as a result of the developments will bring about an increase in souvenir collecting and vandalism. However activities in the area could provide access through excavations to objects which would not normally be discovered.

3.i.2 Historic and Archeologic Impact (Utah)

Tracts U-a and U-b

No archaeological, historic values or other human interest values have been identified on the potential lease tract. However, several off site areas having archaeological or historic values have been identified adjacent to the lease tracts.

3.i.3 Historic and Archeologic Impact (Wyoming)

Tracts W-a and W-b

Land disturbance from road building to waste disposal operations could destroy the values of archeological sites which might be uncovered on the sites or adjacent thereto. Increase in use and accessibility in the area will result in development, increasing souvenir collecting and vandalism.

3.j.1 Grazing Impacts (Colorado)

Tract C-a

The proposed operation of an open pit mine will adversely impact grazing use and area devoted to plant sites, tank farms, overburden waste areas, spent shale dumps, and highways will all be removed from production.

The entire lease area will not need to be removed from forage production at one time; assuming restoration of the mined areas is successful grazing will be displaced for only a portion of the lease period.

On-Site Impacts - It is estimated that 30 per cent of the adjacent area will be out of production or non-usable for a period of fifteen years. This project loss is 180 aums per year for fifteen years.

The quality of the range will be less due to the activity disturbing the livestock. Rate of gain on young animals may be lowered.

Off-Site Impacts - Waste area - 500 acres will constitute a loss of 125 aums per year until revegetation is completed.

The spent shale dump area is located in a winter range. The proposed operation will cover approximately 12,000 acres with spent shale. This will remove 1200 aums of forage if the total area is utilized at one time. Assuming a restoration rate that will maintain the unusable area at 50 per cent the loss will be 600 aums per year.

The utility corridors will not remove a significant amount of forage and restoration is generally accomplished in two years after termination of use.

Tract C-b

The proposed operation of a roam and pillar mine will adversely impact grazing use. Land area devoted to plant sites, tank farms, overburden waste areas, spent shale dumps, and highways will all be removed from production.

The entire lease area will not need to be removed from forage production at one time; assuming restoration of the mined areas is successful, grazing will be displaced for only a portion of the lease period.

On-Site Impacts - It is estimated that 30 per cent of the area will be out of production or non-usable for a period of fifteen years. This projected loss is 195 aums per year for fifteen years or 2925 aums.

The quality of the range will be less due to the activity disturbing the livestock. Rate of gain on young animals will be lowered.

Off-Site Impacts - Waste Area - 500 acres will constitute a loss of 65 aums per year until revegetation is completed.

The utility corridors will not remove a significant amount of forage and restoration is generally accomplished in two years.

3.j.2 Grazing Impacts (Utah)

Tracts U-a and U-b

Domestic Animals - Some domestic use by sheep will probably be eliminated during the development period. Conflicts with surface reclamation and general mine operations may eliminate use for an extended period of time. A total of 730 available AUMs will be affected by this program.

3.j.3 Grazing Impacts (Wyoming)

Tracts W-a and W-b

If the entire acreage of the nominated sites were restricted to livestock grazing, approximately 1250 AUMs (60% of which would be in the Cow Creek and 40% in Espitalier allotment) would be lost to the operators who use these areas. However, it is not expected that the entire area will be closed to livestock grazing at one time. It is estimated that at the peak of production as much as 25% of the grazing use will be lost through removal of the vegetation and another 10% because of traffic.

3.k.1 Improvements (Colorado)

Tract C-a

Activities associated with oil shale development would detract from the attractiveness of the site as a hunter camp and would probably eventually render the site unacceptable.

Similarly development activies would detract from the usefulness of the livestock water reservoirs and livestock control fences depending upon the location of the activities. Open pit development would eventually preclude use of existing livestock managment facilities.

Increased use of the truck trails would require upgrading and if the site is developed by open pit mining relocation of the road segments within the site would be necessary.

Tract C-b

Oil shale development activities would detract from the usefulness of the livestock water reservoirs and livestock control fences in the immediate vicinity.

Increased use of existing roads particularly during wet periods would cause deterioration. Substantial upgrading and increased maintenance would be necessary to keep the roads in a serviceable condition.

3.k.2. Improvements (Utah)

Tracts U-a and U-b

The only foreseeable impacts of oil shale development upon existing improvements on these sites is deterioration of the roads and possible interference with use of the sheep holding corral and the cattle handling corral depending upon the actual location of mining and processing facilities.

3.k.3. Improvements (Wyoming)

Tracts W-a and W-b

Deterioration of the existing road in tract W-a is the only foreseeable impact of oil shale development on existing improvements on these sites.

4. Mitigating Measures Included in the Proposed Action

4.a Geology

Design surface emplacement of overburden and spent shale to minimize erosion and underground emplacement to minimize structural weakness and subsidence.

Exercise caution in sampling and excavation operations so that paleontological objects of interest such as plant and vertebrate remains can be recovered for scientific study.

4.b Mining and Development

(1) Design detailed mining, construction, and processing plans that will avoid or minimize adverse environmental impacts and coordinate with surface resource management, and regional development plans of the county and other public agencies. For example backfilling of the mined-out portions of underground mines with processed shale would improve stability of the mine structure, reduce surface subsidence, and reduce the amount of waste placed on the surface.

Coordination and monitoring of plans during the design phase by Federal and State government would enhance this effort.

(2) Withhold development operations until detailed plans are approved by U.S. Department of the Interior.

(3) Require adequate performance bonds to assure compliance with approved development plans as required in proposed lease.

(4) Continually monitor operations so that unforeseen effects will be promptly recognized and development plan adjustments can be made.

4.c Water Resources

The following listed actions may serve to enchance, protect, or mitigate impacts of the Prototype Oil Shale Leasing Program on the environment:

a. Construct detailed mathematical models of ground water movement at each mining site. Collect field data needed to construct and calibrate the model.

b. As well as possible control erosion during construction by mulching, irrigated revegetation, and other methods.

c. Construct sediment traps of adequate size for construction sites, overburden disposal piles, crushed shale piles, and sites of surface disposal of spent shale.

d. Monitor sediment in streams below lease sites.

e. Construct adequate and fail-safe facilities and regulations to prevent oil or wastewater spillage (accidental or intentional).

f. Chemically monitor sediment traps below spent shale disposal sites.

g. Chemically monitor aquifers near surface spent shale disposal sites.

h. Consider covering (plastic, asphalt, or other material) shale disposal piles.

i. Backfill underground mining works to prevent subsidence.

j. Monitor chemical quality of water in the area of backfilled mines and subsurface injection sites.

k. Monitor possible leakage from evaporation ponds.

l. Conduct additional research on leaching from spent oil shales, surface and subsurface.

m. Treat and monitor all sanitary and process wastewater to meet state and federal standards.

n. Explore and mathematically model hydrology of possible subsurface sites for wastewater injection.

o. Develop a water plan to consider supply and wastewater disposal for an increased population.

The above listed mitigating measures, if fully employed, may actually result in an improvement in the quality of streams. This effect will result from discharging waters to streams that are of better quality than the present streamflow.

4.d Wildlife

The anticipated net environmental impacts to fish and wildlife resources of the proposed prototype oil shale leasing program were identified and assessed for individual Colorado, Utah, and Wyoming lease tracts in the previous chapter. Those specific provisions incorporated in the prototype oil shale development program, designed to prevent and/or to mitigate environmental damage to fish and wildlife values, are herein described for the individual selected lease sites.

Reference is made to Chapter IV of the Draft Environmental Impact Statement for the Prototype Oil Shale Leasing Program, prepared June, 1971, in that many of the protective or mitigating features described for the overall program are specifically applicable to each of the individual test-lease sites selected for prototype oil shale processing operations.

In reference to the mitigation of adverse wildlife impacts, the Department will formulate specific environmental criteria, controls and constraints for incorporation into oil shale leases issued under the proposed program. Such lease stipulations will be based on all available information, or as may be additionally derived from further Department field studies or other qualified sources. The purpose of these lease provisions will be to provide full assurance that controllable adverse environmental effects will be, in fact, controlled.

Any development plan shall include, but not be limited to, a detailed project analysis of (a) the amount and types of expected waste materials; (b) the location and extent of residue disposal areas; (c) the types of vegetation and reclamation procedures to be used in land restoration; (d) the time schedule for restoring the lands; and (e) a showing to the satisfaction of the Department that the disposal and restoration system has been designed so as to protect the long-term biotic productivity of affected areas.

Operations conducted by the lessee under the development plan shall be subject to continuing monitoring by such officials as may be designated by the Department.

An important objective of this prototype oil shale development program is to compare the actual environmental impact with the anticipated impact. If it is found that overall mining processing and marketing operations do not meet the standards specified in the oil shale lease stipulations, an immediate adjustment of operations would be made to control or offset adverse effects pursuant to the regulations, operating plan, and the terms of the lease.

With current information, environmental agencies and organizations can help the oil shale industry minimize the adverse impact of scheduled operations and activities on fish and wildlife resources. Included are the handling of topsoils, waste materials and surplus waters; the location and design of roads, fences, pipelines or utilities; the control of access; as well as the prompt rehabilitation of all disturbed habitat areas.

Although much progress has been made in the science of range revegetation, the successful restoration of spent shale deposits to a former sustained level of productivity for wildlife remains unproven. Such desired breakthrough appears dependent upon the application of a number of specific cultural methods or techniques not currently available.

Since cash flows involved in oil shale extraction are expected to be of considerable magnitude per unit of area mined, the cost associated with environmental safeguards and rehabilitation efforts should not be a factor limiting prompt attention. With adequate funding available at the outset of test-lease operations, research efforts could be directed toward the establishment of needed wildlife-environmental rehabilitation standards.

Anticipated progress in the development of a new oil shale technology must be simultaneously matched by research with similar progress in the development of the environmental technology required to both protect and restore affected fish and wildlife habitats.

Specifically pertinent wildlife oriented research will be undertaken upon the initiation of oil shale operations, ancillary development, and resulting population pressures, with particular reference to specific new problems encountered during on-going monitoring activities. Support for systematic research and field evaluation will be obtained from both the private and public sectors to resolve problems related to individual fish and wildlife species, as well as to improve the skills and materials needed to properly revegetate disturbed areas.

The Department, through its Bureau of Sport Fisheries and Wildlife, and in close cooperation with the State Divisions of Game, Fish and Parks, universities, and various other private or public organizations will work closely with representatives of the oil shale industry to not only assure protection of the fish and wildlife resources, but, wherever possible, their development and enhancement. It will be necessary that the lessees restore the lands and waters to their former productivity, as well as to bear the cost of wildlife management and development measures designed to increase the wildlife carrying capacity on unused or restored lands to offset losses occurring on lands in production or as may be occupied by processing and administrative facilities.

Although land restoration objectives will be primarily aimed at replacement and enchancement of winter-range food and cover requirements for the important big game species, including mule deer and antelope, full consideration will be given to the year-long habitat needs of all existing wildlife species when major land rehabilitation and management decisions are made.

a. Mitigating Provisions for Wildlife - Colorado

(1) Test Lease Tract C-a

The major disturbance to surface vegetation and associated wildlife habitats anticipated on the 5,130 acre test site, a 1,000 acre waste disposal area, and the extensive acreage involved in various service and utility corridors, will be restored in a systematic and timely manner.

All such areas will be revegetated with native plants, or equivalent exotic substitutes, of high specific food or cover value to indigenous wildlife species. Replacement vegetation shall be of that species composition and density having the potential of supporting seasonal or yearlong wildlife use-levels comparable or superior to those values existing prior to lease operations.

It is recognized that the establishment of replacement vegetation comparable to that destroyed through a number of anticipated oil shale development operations will be exceedingly difficult, time consuming, and costly. Much of the expected disturbance of surface vegetation within highway, power transmission or pipeline rights-of-way may be subject to soil preparation and seeding with appropriate wildlife food and cover species, utilizing a number of cultural practices currently available for such conditions.

The unvegetated surface of waste disposal areas and heavily disturbed terrain, including overburden deposits, mining wastes and excavation sites, are expected to have severe limitations related to physical structure and chemical characteristics. On such severe sites, timely restoration will be undertaken, utilizing all existing cultural knowledge supplemented by specific research investigations and field evaluations currently underway or in various stages of initiation.

The possibilities of enhancing the revegetation process on severe sites through return replacement of topsoil, or through soil structure mixing of various components will be thoroughly explored. In addition, the application of nursery culture, nursery stock, irrigation, fertilization or specific new hand care techniques developed through research and field evaluation, will be utilized, as necessary, to achieve the early establishment and long-term maintenance of high value vegetation for wildlife.

Basic research in a broad range of revegetation processes will be conducted by the Department, all lessees, and a number of institutions or groups under systematic contractual arrangement.

In further mitigation for wildlife habitat values lost through surface disturbance, and to provide for early replacement forage during long-term revegetation processes, a number of off-site activities will receive primary consideration. Typical examples of practices which may be employed on important off-site tracts, carefully selected through inter-agency negotiations, will include the selective clearing of pinyon-juniper to stimulate the growth and vigor of key browse and cover species of existing vegetation, off-site seed bed preparation and seeding of valuable supplemental food and cover varieties, application of fertilizers to select areas of rangeland, and redistribution of tree, shrub and other vegetative materials removed from mining sites, to cover-deficient areas on nearby range. An additional consideration which provides for the mitigation of wildlife losses will involve the early retirement of public grazing permits at least equivalent to the production of forage lost through overall test-lease operations.

Since much of the anticipated disturbance of fish and wildlife resources is closely related to human activities which will be associated with oil shale development, a number of lease stipulations designed to maintain inherent values, including the semi-wilderness status of the present environment, will be prescribed.

(a) Vehicular access will be limited, within and adjacent to development sites, with much of the land area open to access only by foot or horseback travel.

(b) Vehicular access will be confined, as appropriate, to Bureau of Land Management or State Game, Fish and Parks Division designated roads. All roads classified as suitable only for 4-wheel drive vehicles should be utilized under a permit system other than during authorized hunting seasons, or in conjunction with authorized livestock operations.

(c) Use of off-road vehicles, such as trail cycles, dune buggies or snowmobiles will be subject to Bureau of Land Management and State Game, Fish and Parks Division regulations.

(d) Provision will be made to confine picnicking, day-use and overnight camping to BLM or State Game, Fish and Parks' designated camp or recreation sites.

(e) Provision will be made to minimize adverse impacts associated with the development and maintenance of all mining service or support structures through the careful regulation of access and, as appropriate,

(f) Provision will be made to utilize an area-wide zoning ordinance (currently being developed) which will serve to control the location of off-site communities or service facilities, and to prevent the unregulated urbanization of a region which is primarily rural in nature.

To the extent possible, all presently known natural springs or seeps, having wildlife values, will be excluded from mining processes or avoided during the development of all service facilities. As a means of enhancing the fish and wildlife environment, or in replacement of water resources lost through mining operations, consideration will be given to the construction of low-head dams in suitable canyon drainages. Such structures will be designed to conserve run-off water, and to reduce the transport of silt. In addition. lease stipulations will make provision to prevent downstream pollution which could have significant adverse effects on downstream fishery resources.

The potential adverse impacts to wildlife associated with the development of electrical power transmission structures and utility pipelines, will be minimized through careful planning in their location and design. To the extent possible all required rights-of-way will be selected to avoid the more critical areas. Oil and gas pipelines will entail use of suitable control structures to minimize danger of accidental spills, and effective contingency plans will be utilized to contain such spills if they were to occur. The specifications for construction of electrical-power transmission lines will include the latest safeguards to protect eagles or hawks from accidental electrocution. To the extent possible, all such electrical power will be delivered through underground lines.

A number of practices will be employed as a means of minimizing the adverse effect of increased vehicular traffic on resident wildlife populations, particularly as related to the yearlong movements and seasonal migrations of large numbers of mule deer utilizing the area. In various combinations, dependent upon the specific sites or conditions involved, mitigation measures will include the selective game-proof fencing of major access routes; the use of underpass structures at important deer-crossing sites; and the construction of big game drift fences or other similar protective devices to deter wildlife movement from highway corridors.

In those areas where game-proof fencing would result in an unacceptable disruption of historic migration routes, consideration will be given to the clearing of obstructive cover along both sides of the highway corridors, thus permitting motorists to be aware of wildlife presence and movements. An additional mitigation practice to be considered will involve the development of supplemental food and cover plots in select locations to attract wildlife use away from highways or development sites.

The location or use of all protective facilities or practices will be based on specific recommendations of State and Federal agency representatives entrused with wildlife management responsibilities.

Oil shale development and processing activities will predictably result in the curtailment of public hunting and recreational use of certain land acreage within the designated lease tract and certain associated facility sites. To minimize such loss, lease stipulations will provide that the lessees' authority to deny public use will be limited, except as may be necessary for public safety, or in the maintenance of security and efficiency of operations in the

immediate vicinity of administrative facilities or actual mining and processing operations.

The anticipated area-wide growth in human population and facilitated access associated with test-lease oil shale development, will likely result in increased legal, as well as illegal wildlife harvest pressure. A number of options which may be employed by the Colorado Division of Game, Fish and Parks to compensate for these new demands could include the use of special area licenses or permits, the limitation of public access, confirmed bag checks through increased enforcement, and hunting activities regulated through use of designated camp areas only.

(2) Test-Lease Tract C-b

Surface vegetation, soil structures and associated wildlife habitats, disturbed or destroyed on the 5,114 acre test tract (C-b), as well as on the extensive acreage involved in various service and utility corridors through prototype oil shale mining operations, will be restored to former levels of productivity in a systematic and timely manner.

The specific techniques, methods and objectives described for Colorado Tract C-a, and related use or impact areas, will be primarily applicable in mitigating for all anticipated adverse environmental impacts affecting fish and wildlife resources on Tract C-b and related areas. The close proximity of Tract C-b to the permanent water on Piceance Creek, and the on-site presence of several important tributary streams, however, will entail development of a more elaborate waste retention capability, designed to prevent degradation of downstream fishery resources. Conversely, a less elaborate system of game-protective devices will be required along highway corridors, since development of Tract C-b does not represent the deep penetration of a remote game range as experienced at Tract C-a.

b. Mitigating Provisions for Fish and Wildlife - Utah

(1) Test Lease Tracts U-a and U-b

Surface vegetation, soil structures, and associated wildlife habitats disturbed or destroyed on the two 5,120 acre tracts (U-a and U-b), as well as on the extensive acreage involved in the

supporting service and utility corridors, through prototype oil shale mining operations, will be restored to former levels of productivity in a systematic and timely manner.

The specific techniques, methods and objectives described for Colorado Tract C-a and related use or impact areas, will be primarily applicable in mitigating all anticipated adverse environmental impacts affecting fish and wildlife resources on Utah tracts U-a and U-b and related areas. As outlined for Colorado Tract C-b, the close proximity of Utah test-lease tracts to the permanent water on White River and the on-site presence of several major tributary streams, will entail the development of an elaborate waste retention capability, designed to prevent degradation of downstream waters containing endangered fish species habitats, as well as food-fish populations.

Although historic game migration routes, and seasonal wildlife movement patterns may not be as extensive as described for Colorado Tract C-a, the utilization of various protective features along major vehicular access routes may be required.

Close coordination will be maintained with representatives of the Utah Division of Wildlife Resources in the selection and application of mitigating features or practices involving wildlife resources and their related habitats.

c. Mitigating Provisions for Fish and Wildlife - Wyoming

(1) Test Lease Tracts W-a and W-b

Surface vegetation, soil structures, and associated wildlife habitats disturbed or destroyed on the two 5,120 acre tracts, as

well as on the extensive acreage involved in supporting service and utility corridors through prototype oil shale mining operations, will be restored to former levels of productivity in a systematic and timely manner.

The specific techniques, methods and objectives described for Colorado Tract C-a and related use or impact areas, will be directly applicable in mitigating all anticipated adverse environmental impacts affecting fish and wildlife resources on Wyoming tracts W-a and W-b and all related areas.

Close coordination will be maintained with representatives of the Wyoming Game and Fish Commission in the selection and application of mitigating features involving the protection of fish and wildlife resources, and the restoration of related habitats.

4.e Surface Restoration and Revegetation

It is recognized that severe surface disturbances will be required to mine oil shale with the open pit method. To a lesser degree, underground mining will create surface changes due primarily to deposition of spent shale material. In-situ mining will produce only minor surface disturbances.

As stated in part 1 of this statement, the Department will require in the lease terms and regulations that the lessee restore the land surface to a state commensurate with or better than the original terrain.

To accomplish this objective, a detailed plan for each tract will be developed utilizing the best technology available. It is recognized that soil placement, slope requirements, planting methods, and combinations of conservation practices will be incorporated into land restoration plans to meet the individual tract conditions created by the lessee's operations.

As previously indicated, all tracts nominated are in climatic zones for which adapted plant materials are available or could be produced in time to meet the need.

Vegetative composition within the tracts at the present time varies in relation to site potentials. Historic use by livestock and game animals has caused a change in plant composition because of grazing or browsing of selected plant species. Where perennial grasses have been heavily used by cattle over a prolonged period, there is a resultant increase in big sage brush and invasion by pinyons and junipers. Heavy browsing by mule deer has diminished the more palatable browse plants below the percentage the sites would potentially support.

Several options will be available concerning the type of vegetation to be reestablished. Revegetation plans will be designed to meet the projected future land uses and needs. On many sites, the reestablished vegetation may be superior to that now on the site.

Revegetation will be done according to the latest techniques developed by agencies such as the U.S. Soil Conservation Service, U.S. Forest Service, Agricultural Research Service, U.S. Bureau of Land Management and by appropriate land grant universities.

It is anticipated that the restoration of oil shale development sites will accelerate the study of revegetation methods to meet unique situations in critical area stabilization. As new information is acquired, it will be applied to assure efficient and successful land restoration.

4.f. Air and Noise

All emissions from an oil shale processing plant must meet Federal and State regulations that are promulgated for meeting established ambient standards for particulates, sulfur oxides, nitrogen oxides, oxidants, hydrocarbons, and carbon monoxide. However, none of the above mentioned emission standards deal directly with the type of industrial processes involved in oil shale extraction. Therefore, specific environmental safeguards would be tailored for each site and would be incorporated into the lease to be issued. These requirements are designed to provide assurance that the lessee would: Control effluent gases and particulate matter to such a degree as to meet a Federal Standard of Performance as defined in Section 111(2) of the Clear Air Act, as amended, or to the extent consistent with Federal Law, meet standards established by the states of Colorado, Utah and Wyoming; and design the stabilization of spent shale and other operational solid wastes that will be stored on the surface, in accordance with mine land restoration regulations of Interior and the states involved.

Types of technological air pollution controls available are:

CRUSHERS, TRANSPORT & STORAGE OF SHALE

- Enclosure
- Water Sprays
- Dust Collectors
- Conveyor Covers
- Surge Bin Covers
- Storage Pile Covers

RETORT

- Dust Collectors
- Dust Cyclones
- Dust Scrubbers
- Aerated Coolers
- Wet Scrubbers

UPGRADING

- Process Fuel Sulfur Removal
- Aerated Coolers
- Low Sulfur Fuel
- Combustion Temperature Control

SPENT SHALE DISPOSAL

- Conveyor Covers
- Wetting Water
- Compaction Equipment
- Site Location
- Revegetation
- Mine Disposal
- Disposal Fencing
- Topping

OFFSITE CONTROLS

- Plant Fencing
- Road Paving
- Surface Restoration
- Construction Controls

Little in the way of planning is done to minimize ambient noise levels. With the plethora of sounds emanating from so many industrial operations in shale processing, unless there is a desire or a requirement to minimize noise levels for stated purposes, such as wildlife considerations, the noise levels will be similar to industrial-urban activities elsewhere. Controls of noise could be made, especially on permanent industrial facilities, with selection of proper equipment, and careful maintenance of machinery. Muffling devices on trucks, compressors, etc., could lessen noise levels considerably. However, additional economic burdens on each operation would have to be carefully weighed against the gains expected.

4.g. Recreation and Aesthetics Mitigating Measures

The following measures would lessen or compensate for the detrimental effects of oil shale development on recreational and aesthetic values on all sites.

(1) Locate buildings, plant facilities, waste disposal areas, utility corridors and roads inconspicuously.

(2) Design buildings and facilities so as to be inconspicuous and harmonious with the natural surroundings to the extent possible without seriously impeding the utility of the facilities. Contour waste disposal areas so as to blend harmoniously with existing land forms and revegetate such areas with native type plants as promptly as possible.

(3) Provide facilities for visitor observation and guided tours of mining and processing operations.

(4) Capitalize on opportunities to develop recreational facilities in conjunction with oil shale development facilities, i.e., boat launching ramps and camp facilities on water bodies at water pipeline terminals, etc.

(5) Establish huntable populations of small game animals and birds where feasible to compensate for reduction of mule deer numbers.

(6) Improve access and build campgrounds and other recreational facilities on nearby areas with the potential for increased recreational use such as the White River National Forest and points along the White River.

4.h Land Use

The following measures would lessen detrimental effects of oil shale development on livestock grazing on all sites. See 4.g. for recreational considerations.

(1) Devise grazing management systems in coordination with oil shale development plans.

(2) Construct protective fences along high impact main-haul roads, around impure waters, open pits and other developments that are potential hazards to livestock.

(3) Replace livestock waters that are eliminated.

(4) Improve the grazing capacity of adjacent lands through management and/or cultural means.

4.i. Urban and Socio-Economic

Measures that could mitigate adverse urban impacts and socio-economic effects of oil shale development stem primarily from urban and regional development planning activities. Basic information is needed on the magnitude and pattern of population and income changes, housing and community needs and potential of existing community and land resources. Plans to guide orderly urban and regional development could materially lessen adverse effects and enhance beneficial effects. Federal and state programs and funds could bridge the lag between increased demand for community services and increased tax base required to finance the same. Studies presently being promulgated by the State of Colorado and the recent formation of an Oil Shale Regional Planning Commission, including the three Colorado oil shale counties, are significant steps toward orderly development.

4.j. Historic and Archeologic

The following measures could avoid or reduce adverse effects on archeologic values.

(1) Proceed with caution in exploratory and development operations and provide trained archeologic monitoring so that archeologic values can be promptly identified.

(2) Promptly notify the Secretary of the Interior when objects of possible archeologic significance are discovered.

(3) Take steps to provide for protection and preservation as directed by the Secretary of the Interior.

5. Any adverse effects which cannot be avoided should the proposal be implemented.

5.a -- Aesthetics - All Tracts

Mining, plant construction, operations, waste disposal, and associated activities will lead to some effects which are both adverse and unavoidable. These unavoidable adverse effects are discussed in this section.

Development of an oil-shale mining-processing-waste-disposal complex on the selected tracts would require roads, mining, and plant sites, waste disposal areas, utility and pipeline corridors, and associated services during the productive life of a lease. These activities would change the existing pattern of land use and alter the existing topography.

Estimates of the size of the area affected at a given site on the basis of 100,000 and of 50,000 barrels per day production, were given in Section 3 for various methods of mining and waste disposal, and for operations involving shale oil upgrading and retorting. These estimates show that for underground mining and surface disposal of processed shale about 56 to 80 acres per year would be required for solid waste disposal plus a total surface area of about 200 acres for facilities and housing and from 100 to 200 surface acres for off-site requirements (access roads, power, water, and oil pipelines).

If 60% of the process shale is disposed underground, an estimated 22 to 32 acres per year would be required for solid waste disposal plus 100 acres for the first 3 years of production. Surface acreage for facilities, housing, and off-site requirements would remain the same.

For surface (open pit) mining and return of overburden to mined-out areas of the pit when space is available would require an estimated 1,000 acres for the first 16 years of production. Mine development would require about 400 to 500 acres per year depending on thickness of overburden and oil shale

beds. Off-site disposal of processed shale would require about 120 to 160 acres per year. A total surface area of about 150 acres would be required for facilities and from 100 to 200 acres for off-site requirements. If processed shale is returned to the pit when space is available, an estimated total of 450 acres would be required for disposal offsite. Acreage for facilities and off-site requirements would remain the same.

For in-situ extraction with surface wells, total surface land area requirements are estimated at 65 acres for facilities and 100 to 200 acres for off-site requirements.

For in-situ extraction using underground mining and in-situ recovery, total surface land area requirements are estimated at 68 acres for facilities, 900 acres for surface disposal of processed shale, and 100 to 200 acres for off-site requirements.

For a combination of in-situ extraction with surface wells and underground mining -- in-situ extraction, total surface land area requirements are estimated at 65 acres for facilities, 450 acres for surface disposal of processed shale, and 100 to 200 acres for off-site requirements.

Waste disposal areas on flat land would create new "hills", which could be contoured and revegetated to restore scenic attractiveness. Canyon and gully disposal areas would gradually be converted into flatter areas, and also revegetated.

To some extent, these changes in topography would alter the appearance of the land and would affect natural vegetative cover until revegetation operations began. These changes would be adverse, in the sense that the area's present topography and semi-wilderness character would be altered. The degree to which these topographical changes are adverse, however, is a value

judgment difficult to quantify. With proper restoration methods the scenic impact would be kept within limits acceptable to most people. Some enhancement might result, especially where areas are now deeply eroded, sparsely vegetated, and essentially unattractive.

5.b. Water - all tracts

Stream courses and channels will be diverted because of mine facilities and waste disposal areas. The quantity of impact depends upon the type and intensity of mining operations and control measures used.

In the case of open pit and shaft mining, it would be necessary to remove and dispose of large quantities of water of varying quality. This would be accompanied by possible detrimental changes in ground water movement, water levels, spring flow and water quality.

During the period between disturbance of the surface and revegetation high intensity rains may cause accelerated soil erosion and channel cutting and may increase sedimentation in the stream beds. Potable waste water discharged into the streams could add to the erosion factor and sediment load, unless properly released.

5.c. -- Wildlife - All Tracts

The unavoidable environmental impacts which are basically common to all proposed oil-shale development sites and related use areas in Colorado, Utah, and Wyoming, may be categorized on the basis of the various factors involved. The major differences in the degree of impact between individual tracts are noted.

(1) Intrusion on Environment

The valuable wildlife resources, currently utilizing proposed lease areas are the result of a uniquely productive habitat, which would suffer a degree of degradation through proposed oil shale development. Construction and operation of proposed mines, together with the anticipated ancillary developments, will encroach upon the semi-wilderness state of the environment. Once semi-wilderness is opened up, it cannot easily be restored.

Improved access to additional areas will be facilitated, and the associated human activities will be expected to have a deleterious effect on a number of fish and wildlife species and habitats. Although all test-lease sites will be similarly affected, the net loss of quasi-primitive qualities at Colorado Tract C-b will be of least significance, since it lies adjacent to a surfaced highway, and in closer proximity to existing population centers.

(2) Physical Effects

During proposed oil shale development operations some accidental siltation of streams and impoundments could occur, with resulting adverse effects upon fish and those mammal species, such as beaver, mink, and muskrat, associated with aquatic environments. In most cases siltation

damage would not be permanent, but may cause temporary loss of production. In some cases, siltation may result in the local loss of downstream fishery resources, through degradation of aquatic habitats.

The potential for accidental impacts through siltation will be of greatest consequence in the vicinity of Colorado Tract C-b and Utah Tracts U-a and U-b, since they lie immediately adjacent to free flowing streams, namely Piceance Creek and the White River, respectively.

(3) Fish and Wildlife Disturbance

Increased human activity, habitation, disturbance, and mechanical transportation are expected to have continuing disruptive effects on numerous wildlife populations. Those species which are relatively intolerant of human activities may vacate disturbance areas, or experience a general decline in population status. Human accessibility to former remote areas would increase hunting and fishing pressure, with an accompanying decline in the quality of such recreational pursuits. Rare or endangered fish, bird or mammal species now present are obviously existing under such delicate ecological balance that any modification of the environment could cause extirpation from the area of test-lease operations. All proposed development sites would be subject to similar disturbance factors.

(4) Wildlife Food and Cover

Development areas affected by construction or surface disturbance may be changed ecologically to the extent that native flora may suffer permanent loss. Within all disturbed areas, the sum total of activity will serve to compact, shatter and disrupt the protective vegetative cover and soil surfaces, which in turn affects permeability, water retention, nutrient cycling, and resistance to wind or water erosion.

All proposed prototype mining and processing tracts identified in Colorado, Utah and Wyoming will be subject to major disturbance through excavations, leveling and construction operations, or waste disposal practices. As a result, systematic restoration programs will be required as a means of returning such areas to suitable levels of productivity.

Vegetative rehabilitation success is dependent upon soil quality, water availability, level of nutrients, and plant vigor. Rarely is the reestablished vegetation on disturbed sites as productive or as suitable to wildlife species as the endemic food and cover plants, therefore, a long-term reduction in the value of wildlife habitats on all heavily disturbed development areas, may be experienced.

5.d. -- Historical and Archaeological

Although there are no known historical or archaeological sites on the selected tracts, evidently the area including the sites was formerly inhabited by nomadic, hunting, Indian tribes (2.1, 3.i). Any disturbance of the surface, especially an open pit mining operation, may disturb some hitherto unknown archaeological sites or artifacts.

5.e. Air and Noise - all tracts

Given the relatively unspoiled air environment of the three remote basins, there is likely to be some air degradation, the extent of which will be determined by the relative merits of environmental protection and economic benefits.

The operations conducted under the prototype program would not be expected to present any unique air pollution problems. Proper techniques already exist to adequately control emissions, including particulates, sulfur oxides, and nitrogen oxides potentially present in various flue gases, and the dusts produced in mining and shale disposal.

It is not implied, however, that a requirement of zero air pollution could be imposed as a standard for the prototype program. Such a standard is not technically or economically feasible. However, it would be expected that all applicable Federal and State criteria on acceptable air quality standards could be met. Residual concentrations of sulfur and nitrogen oxides in flue gases after treatment, and from some solid particulates in gaseous discharges to the atmosphere would be minimal, but unavoidable for the program at the present state of technology. New control techniques now being developed for other industrial operations could be incorporated into this industry, which is at least 2 and, possibly 4 years from construction.

The Clean Air Act provides a nondegradation clause, that existing ambient standards are not construed to sanction a decrease in the quality of the air; however, the National Environmental Policy Act requires economic considerations as part of environmental assessment. Thus the ultimate air quality is subject to negotiation for the oil shale process.

It is highly unlikely that a general increase in the noise level can be prevented, wherever full oil shale production is developed. The thrust of urbanization and industrialization is marked by other features besides noise levels, such as mobility in and intensive human use of surrounding areas, trash accumulation, etc. The impact on wildlife and extant scenic values in the area will be modified even if noise is carefully controlled.

5.f Grazing

Varying acreages of land now used for livestock grazing will be eliminated from this use during mining operations and the period during which vegetation is being reestablished. The extent of this acreage will depend upon the type of mining method used. It could be as high as 3500 acres on Tract C-a if an open-pit operation is selected, or as low as 100 acres on Tract W-a if an in-situ operation is selected.

6. The Relationship Between Local Short-term Uses and the Maintenance and Enhancement of Long-term Productivity

6. The Relationship Between Local Short-term Uses and the Maintenance and Enhancement of Long-term Productivity

In summary the present long-term productivity outlook in the Rio Blanco area would be limited to livestock raising, agriculture, recreation, oil and gas production, and minor community business services.

Agriculture is mainly limited to the raising of livestock feed, as well as some grains. Cattle comprise the major portion of livestock holdings, although a significant number of sheep are present in the county. Deer hunting is the major sport in terms of annual hunter population, during limited periods. Mineral recovery is limited almost entirely to the gas and oil industry, with one major producing gas field north of Piceance Creek, and two oil fields -- one in the Rangely area, and the other in the vicinity of Wilson Creek.

6.a. Energy and Mineral Resource Gain

These leases would provide a basis for recovery of 14 million barrels of prime recoverable reserves (35 gallons per ton with a thickness of 30 feet) and ultimately establish as a petroleum reserve at least an additional 168 million barrels of oil in a firm capacity. This development would provide an option to utilize and develop marginal and submarginal resources prior to critical energy demands, either long term or emergency situations.

The tracts proposed for leasing in Colorado would activate an option to develop a secondary source of alumina by making available the mineral dawsonite which occurs in the lower oil shale zones. Development of this mineral as source material could mitigate the U. S. dependence on foreign imports.

6.b. Technology Gain

Orderly development of these oil shale lands will provide new design technology for environmental situations and for new and improved mining and industrial equipment. Current deficit of minerals consumed in the U. S. is about 22%. It is estimated that this deficit will rise to 50% by 1999. This will create an increased dependence on imported minerals which may not be available to us. The alternative is to improve current technology for extracting mineral wealth from known unexploited domestic deposits. It is anticipated that a large oil shale industry will provide the incentive needed to develop new and improved mining and materials-handling technologies which may also be used for developing large low-grade deposits of other minerals that are now lying idle.

The development of lands in Colorado could provide a substantial amount of nahcolite which could be utilized to reduce air pollution in many coal burning facilities.

It is anticipated that the restoration of oil shale development sites will accelerate the study of stabilization and revegetation methods to meet unique situations in critical area stabilization programs. As new methods or information are acquired, it could be applied to assure efficient and successful land restoration in other critical areas. In the long term, the lands could be returned to comparable present usages with up to 40% increased productivity.

6.c. Short-term -- long-term relationships:

Possibly the relationship of environmental impact to time and rate of oil shale production will generally be linear, i.e., adverse effects will increase proportionately. However, some problems that may become disproportionately more accute with time and production rate are:

a. Effects of ground-water pumpage on aquifer pressure, lowering of water levels (and pumping levels) followed by decrease in quantity of spring and stream flow.

b. Excessive ground-water pumpage could change hydraulic gradient particularly in Colorado and cause mineralized water to move toward pumped wells and pits. The quality of water available for human and industrial use could be effected.

The development of these leases, however, could provide a body of hydrologic knowledge with which better water utilization could be accomplished and better pollution and technical control measures established.

6.d. Short-term Uses of the Environment vs. Maintenance and Enhancement of Long-term Productivity

Fish and Wildlife Resources

The prototype oil shale program and associated urban development would result in certain localized, as well as regional, adverse impacts on fish and wildlife resources. The areas identified as test-lease tracts in Colorado, Utah and Wyoming, together with the related service and utility corridors, will involve a limited percentage of lands in the overall three-state region, however, the sum total of proposed industrial activities will exert a considerable impact on the existing environment well beyond such designated boundaries.

Existing land-use programs, on and in the vicinity of all proposed test lease tracts in the oil shale region, involve the coordinated management of domestic livestock and fish and wildlife resources as well as the

provision of quality recreational opportunity, on a continuing, sustained production basis. Some limited additional disturbance related to future oil, gas, or mineral development may be anticipated, however, in the absence of prototype test-lease activities it can be assumed that current levels of wildlife productivity, species distribution, and recreational use, could be maintained on a continuing and sustained-yield basis.

Although some impacts related to proposed oil shale processing activities would be unavoidable, many lend themselves to technological and regulatory control. The objective would be to maintain existing habitats with as little disturbance as possible. Therefore, the optimum relationship between program implementation and maintenance of long-term wildlife productivity would involve cooperation among the government, industrial and private sectors in anticipation of adverse impacts, and implementation of continuing research, development and control programs which would preclude, minimize, or mitigate the adverse impacts.

6.e. Development and Productivity of the Area

Although the initial construction phases related to the proposed leasing would involve some burdens on the seven county region, an integrated development could serve as model for the evolution of a rural area to urban and partially industrialized socio-economic structure.

The development would provide a stable tax base over a long term for semi-isolated areas. The trend in depleting population, particularly in Colorado and Utah, could be offset by new training and additional job opportunities. Due to the population increase with a stabilized industry of this magnitude the communities could have social services and facilities which are now minimal or lacking.

6.f. Recreation and Aesthetics

With the restoration and rehabilitation of the lands to a comparable or better condition and uses, the recreation and aesthetic potential could be modified with the addition of reservoirs both in the lease areas and appurtenant region.

6.g. Historic and Archaeological

It may be assumed that both archaeological and historical Indian sites may be found near water sources in the area of the tracts. A major problem in surveying for these sites is the evidence of rapid erosion in the areas. Deposition many feet thick, which has occurred in the last several hundred years in the valleys may have buried the sites in existing stream beds. Excavation activities would assist in revealing these past records.

It is concluded that the value added from the productivity of the oil shale and the associated minerals both to the regional and national well being far outweighs the temporary loss of the existing grazing and hunting uses and environmental disruption.

7. Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

7.a. Consumption of Mineral Resources

It is estimated that the oil shale deposits in the Green River Formation in Colorado, Utah and Wyoming contain approximately two trillion barrels of oil in shale beds that average at least 15 gallons of oil per ton in units 15 or more feet thick. About one quarter of the resource, 500 billion barrels, is contained in richer oil shales that average 30 gallons of oil per ton.

If one of the selected tracts which lends itself to open pit mining produces at the rate of 100,000 barrels per day a total of 67.5 million barrels of oil will be produced in the first four-year development period. In the remaining 16 years of the lease an additional 560 million barrels will be produced. Assuming a production rate of 50,000 barrels a day for the remaining 5 selected tracts a total of 170 million barrels will be produced in the first four years and an additional 1,440 million barrels in the remaining 16 years of the lease. Assuming a 60% recovery factor about an additional 1,070 million barrels may be lost in mining.

In addition to the 3.3 billion barrels of oil produced and lost in mining in the three state area millions of tons of dawsonite and nahcolite will be mined in the Piceance Creek Basin of Colorado.

7.b. Changes in land use patterns, visual aspect, and ecosystem

The proposed oil shale developments would constitute an industrial encroachment upon the relatively unchanged natural environment and bring about certain biotic, visual and land use changes of a lasting nature.

In addition to mine excavations, waste piles, water control structures, buildings and other physical facilities the increased human activity will inevitably result in some changes in the visual aspect of the development areas.

Improved access and increasing human populations will result in additional hunting, fishing and other recreational pressures, with an unavoidable reduction of hunting and angling quality for some species and in local situations.

Operations at and in the vicinities of oil shale installations will entail localized and permanent reduction of habitats, as well as a disturbance to wildlife populations over the life of the programs. Some specific areas may be changed ecologically to the point that certain

existing native flora may suffer permanent loss. Although the changes may not be dramatic, increased ancillary urbanization and human pressures resulting from the prototype program would create an impact on rare and endangered wildlife species, as well as on others of the less tolerant nature, through the progressive deterioration of the quality of their essential habitats, or the imposition of various stress factors.

The lands involved in mining operations, treatment plants, and ancillary facilities will be dedicated to this single use for the life of the project and consequently unavailable for other uses.

7.c. Water resources

Between 50 and 100 acre feet per day of surface or underground water will be used in mining, crushing, retorting and waste disposal on the six selected tracts. Part of this water will be diverted from the Colorado, White and Green Rivers and will not be available for some later as yet unanticipated need.

Pumping to dewater mine areas in Colorado may result in establishing a cone of depression which may in turn lead to encroachment of highly mineralized ground water into the lease area. Dewatering the leached area in the Piceance Creek Basin may lead to compaction of the Green River Formation and possibly ultimately cause local land subsidence and drying up of springs with a consequent adverse effect on animals and plants.

8. Alternatives to the Proposed Action

8.a. Energy Alternatives

The need for a national energy policy has been confirmed by a combination of factors involving international policies and trade, development of new ecologic insights and revised estimates of domestic energy resources available within economic limits. The Nation's resource base of fuel minerals is ample to meet demands but the objective is to identify and delineate these resources and to develop the technology for their wise use as clean fuels at a reasonable and competitive cost. In addition, such national objectives as national security, conservation, environmental protection, consumer protection and international trade are increasingly being considered in the provision of adequate energy supplies.

Environmental considerations have impacted domestic exploration and development, notably delaying marketing of Alaskan production; restricting Santa Barbara Channel development; postponing Federal offshore leasing and rigidly controlling offshore production practices. Therefore, to increase domestic oil supplies, it is considered necessary to: (1) reconcile environmental and energy objectives with precautionary measures necessary to hold environmental damage risk within acceptable limits; (2) provide an investment climate which will attract risk capital to domestic oil ventures; and (3) invest in new technology to provide more efficient methods of oil discovery and production. Without increased domestic exploration and production, greater dependency on foreign imports will result and at a time when foreign owners are becoming more demanding

and imported crude prices are increasing. These factors become quite important because for the foreseeable future, petroleum is generally regarded as the swing fuel, to replace those fuels necessary for economic growth while they catch up environmentally.

For long-range petroleum needs, alternative sources of synthetic crude may be available from coal conversion, oil shale and tar sands. However, to date, only one Canadian tar sand plant has operated at a commercial level. The other options for energy supplements are currently undergoing extensive pilot studies.

The overall energy mix required to meet our projected demands are analyzed in many public and private studies including the Draft Environmental and Program Statements for the Prototype Oil Shale Leasing Program and the Alternative in Environmental Impact Statement for the Alaska Pipeline. Based on the findings of such studies, it is assumed that energy from oil shale sources will be required as a function of our energy complex and phasing in by 1980. In order to gear actions and evolutionary progress to meet these goals, other alternatives systems are considered.

8.b. Technical Alternatives to Oil Shale Development

The four basic alternatives which exist for oil shale development are:

(1) Conventional extraction by surface or underground mining with surface processing of the raw material either by competitive industry development or Government development.

Several operations have been conducted on a pilot scale, at maximum throughput of 1,000 tons of oil shale per day, by the U. S. Bureau of Mines and industry. Although a surface mine has never been established in the oil shale of the Green River Formation, oil shale on mainland China and Russia and copper and other minerals in the United States are now being mined in large open pits. Equipment and technology used in these operations may easily be tailored to mining the Green River oil shales.

(2) In situ retorting utilizing conventional fracturing methods followed by petroleum extraction through wells.

At present the U. S. Bureau of Mines in Wyoming and Shell and Atlantic Richfield-Equity Oil Companies in Colorado are experimenting with in situ retorting methods in the Green River oil shales. Available information on the results of these experiments indicates that in situ retorting extractive technology lags many years behind that of conventional mining and retorting methods.

(3) In situ retorting utilizing nuclear fracturing followed by petroleum extraction through wells.

CER Geonuclear has proposed a joint AEC-industry nuclear fracturing experiment in the Green River Formation on Utah State oil shale leases. Previously an attempt was made to interest the Federal Government and industry in a similar proposal in the oil shale of the Piceance Creek Basin in Colorado. Until an experiment of this type is conducted, the technological and economic feasibility of nuclear fracturing will not be known.

(4) Combination underground mining and surface processing followed by in situ retorting methods after underground opening and fracturing have been accomplished.

This will be a second stage in the development of an oil shale industry to be conducted after a segment of the underground mining is completed. A method similar to this was utilized in Estonia prior to and in Germany during the latter stages of World War II.

8.c Alternatives to Number, Location and Size of Present Tracts

(1) Number of Tracts Selected

As an alternate to the present selection and designation of six tracts in three states, it is possible to consider the leasing of either fewer or more tracts. Fewer tracts would obviously result in reduced environmental disturbance, while a greater number of tracts would permit even broader industry participation and the examination of more of the parameters affecting oil shale development.

The selection of fewer tracts would naturally reduce the opportunity for competitive development, thus concentrating technical and management expertise, and eventually even economic gain in the hands of only a few companies. In addition the number of different technologies which could be examined and the variations in geologic conditions and other environmental parameters which could be studied would also be less.

Alternatively, a greater number of tracts would eliminate most of the objections previously mentioned but would increase the opportunity for environmental disturbances. After careful consideration it was felt that six sites, equally disbursed between the three oil shale states would provide the diversification in geologic conditions needed, would permit the testing of a variety of technologies, would enable broad industry

participation and would produce environmental risks which could still be considered within tolerable limits.

(2) Location of Selected Tracts

In selecting the six final sites from the twenty tracts nominated by industry (thirteen in Colorado, four in Utah, three in Wyoming) consideration was given to providing for the overall prototype leasing program, the best possible balance between diversification in the development in technologies, examination of environmental impacts, and the variations due to locale. It is recognized that other alternative choices in the locales of the six sites might have been made, but probably only at the expense of some compromise of the program as a whole.

In Wyoming the similarity of the three nominations made the selection of two tracts uncomplicated. In Utah the two sites selected are amenable to either conventional or in-situ mining. Other nominations posed problems in the amount of reserves present, the depth of the deposits, etc. In Colorado one of the two sites selected is particularly amenable to surface mining, and the other to underground mining. Other nominations posed difficulties in such matters as excessive amounts of water in the shale strata, the absence of a lower shale zone, the presence of highly saline water in the leached zone, and potentially objectionable concentrations of halite.

As an alternative in some of the above cases it would have been possible to ignore the sites nominated by industry, and select instead tracts proposed by one or more federal agencies. This was felt to be particularly undesirable since it is to be industry which must expend the effort and funds to develop the leases to be issued. (The absence of industry participation in the nomination process was probably an important deterrent to success in the 1968 leasing program.)

(3) Size of Tracts

The 5100 acre tract is the maximum size permitted for leasing by the Department of Interior under the present Leasing Act. New statutory authority would be required if, as an alternative, larger tracts were to be offered for lease. It was felt that in this first prototype leasing program the major objectives sought could be accomplished within the limitations of the 5100 acre size.

Another alternative would be to offer leases smaller than 5100 acres. However, it was felt that this might compromise the technological developments which were being undertaken, and also could result in less than a full-scale assessment of any environmental problems which might arise.

SUMMARY

SUMMARY

To stimulate technology and commercial development of oil shale, the Interior Department announced on June 29, 1971 plans for a proposed program to permit the development of a small part of the oil shale resources on public lands in Colorado, Utah, and Wyoming. A preliminary Draft Environmental Impact Statement was also released at that time. The prototype program would involve public and industry participation in selecting up to six oil shale tracts--two in each of the three states--to be offered for lease by sealed, competitive bonus bids. The first leases, subject to detailed environmental safeguards designed for each individual tract, would be issued in December 1972 if the tentative timetable is followed. No shale oil is being produced commercially in the U.S. at this time.

This document is a supplemental draft environmental statement for six tracts which have been selected for competitive lease offering under the proposed program.

Fifteen companies submitted 23 nominations (17 in Colorado, 5 in Utah and 1 in Wyoming) of tracts for lease offering. At the suggestion of the State of Wyoming, two other tracts were added in Wyoming. Based upon criteria such as environmental factors, geologic setting, recoverability and apparent interest, two tracts in each of the three states have been selected for the proposed lease offering.

There are four basic development technologies which have been proposed for the recovery of shale oil. The status of these systems are:

1. Conventional underground operations - general technology is developed with a 1000 tpd pilot operation on private land now being conducted.
2. Open-pit operations - general technology is developed on other mineral deposits.
3. In-situ extraction - research and small experimental operations being conducted on private land holdings. Proposals include nuclear fracturing. Total technology is uncertain.
4. Combination underground - in-situ; conceptual studies with minimal research. Requires progressive phases and research to determine feasibility of technology.

The present uses of the tracts proposed for leasing and appurtenant areas are limited to livestock raising, deer habitat, and hunting and related camping.

The development of these tracts including service facilities and associated urban development would cause localized as well as regional impacts by modifying rural socio-economic structure to partial urban-industrialized structure and wildlife habitat in the affected areas.

Orderly development of these oil shale lands will stimulate new design technology for environmental and mineral development situations, and development of potential source of alumina (dawsonite) and material for reduction of air pollution (nahcolite).

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